

Usability Evaluation of Speech User Interfaces for Three Currency Conversion Prototypes

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Abstract

This study compared the usability of three half-duplex speech user interface prototypes for currency conversion. The users' primary objective was to obtain correct conversion rates and amounts for two conversion tasks in which proper specification of the direction of the conversion was critical for successful task completion. In addition to conversion direction errors, users also experienced two types of turn-taking errors (spoke-too-soon and spoke-way-too-soon errors). We provide ten recommendations designed to (1) reduce the likelihood of direction and turn-taking errors and (2) reduce demands on user memory when listening to long system messages (introduction and presentation of conversion rates).

ITIRC Keywords

ViaVoice

Automated Speech Recognition (ASR)

Speech User Interfaces

Telephony

Currency conversion

Spoke-too-soon error

Spoke-way-too-soon error

Usability Evaluation

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Introduction

The purpose of this study was to compare the usability of three currency converter prototypes that used telephony-based speech user interfaces. The local currency for these prototypes was the Australian dollar¹. Each prototype allowed users to obtain the conversion rate between Australian dollars and other major currencies. The prototypes also permitted users to convert a specific amount of Australian dollars into foreign currency or convert a specific amount of foreign currency into Australian dollars.

It is important to note that the direction of conversion influenced the conversion rates. For example, when using Prototype A or B² to convert to (or buy) German marks, the exchange rate was 1.06578 German marks per Australian dollar. However, when converting from (or selling) German marks, the conversion rate was 1.30262 German marks per Australian dollar. Therefore, determining and specifying the proper direction of conversion was critical to the users' primary objective of obtaining accurate conversion rates and amounts.

Each prototype varied regarding the prompts presented to users when obtaining conversion rates and conversion amounts. Prototype A prompted users to buy or sell foreign currency. Prototype B prompted them to convert to or from foreign currency. Prototype C converted the rates and amounts in both directions and left the user to decipher which was appropriate for their specific transaction goal. The following scripts illustrate successful task completion with each prototype for the task of acquiring 500 German marks.

Prototype A

System: Welcome to the AussieBank international conversion system. This system provides exchange rates between Australian dollars and the major currencies of the world. Speak to the system after you hear the beep. The options Help, Repeat, Cancel and Start Over are always available. Do you want to **buy** or **sell** foreign currency?

User: Buy.

System: Buy currency from which country?

User: Germany

System: Our current conversion rate is 1.06578 German marks per Australian dollar. How many German marks would you like to buy?

User: Five hundred.

¹ The motivation for constructing these prototypes was a request from IBM customer representatives in Australia. The participants in this study were U.S. residents who received scenarios asking them to assume that they lived in Australia. The recognizer's acoustic model was U.S. English.

² The conversion rates were slightly different for Prototype C. These differences are not important.

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System: 500 German marks converts to 469.13 Australian dollars. Would you like to do another transaction?

User: No.

System: Thank you for calling. Goodbye.

Prototype B

System: Welcome to the AussieBank international conversion system. This system provides exchange rates between Australian dollars and the major currencies of the world. Speak to the system after you hear the beep. The options Help, Repeat, Cancel and Start Over are always available. Do you want to convert **to** or **from** foreign currency?

User: To.

System: Convert Australian dollars to currency of which country?

User: Germany

System: Our current conversion rate is 1.06578 German marks per Australian dollar. How many German marks would you like to convert?

User: Five hundred.

System: 500 German marks converts to 469.13 Australian dollars. Would you like to do another transaction?

User: No.

System: Thank you for calling. Goodbye.

Prototype C

System: Welcome to the AussieBank international conversion system. This system provides exchange rates between Australian dollars and the major currencies of the world. Speak to the system after you hear the beep. The options Help, Repeat, Cancel and Start Over are always available. Which country?

User: Germany

System: We currently convert to German marks at the rate of 1.243410 German marks per Australian dollar and from German marks at the rate of 0.88889679 Australian dollars per German mark. What amount would you like to convert?

User: Five hundred.

System: 500 German marks converts to 402.11 Australian dollars and 500 Australian dollars converts to 562.49 German marks. Would you like to do another transaction?

User: No.

System: Thank you for calling. Goodbye.

The prototypes were half-duplex systems³ (in other words, did not allow barge-in), accepting participants' speech only after a tone indicated it was their turn. The prototypes contained self-revealing help prompts at each turn to guide the user through the transactions (Balentine and Morgan, 1999; Lewis, Simone, and Bogacz, 2000). For example, prototype A prompted the user, "Would you like to **buy** or **sell** foreign currency", (with emphasis on the words "buy" and "sell" to encourage users to respond with one of those words). If the user did not speak during the recognition window (resulting in a silence timeout after seven seconds of silence), spoke a phrase that was not in the current input grammar, or asked for help, then the prototype presented a self-revealing help prompt to the user. For example, the self-revealing help prompt for this dialog turn in Prototype A was, "Please say either 'buy' or 'sell'."

These prototypes used recorded prompts rather than text-to-speech (TTS) for machine output. The speaker had prior professional recording experience, and attempted to speak at the same volume and speed, using SoundForge⁴ to record the prompts as 8 kHz 16-bit mono pcm wavefiles. For these prototypes, there was no attempt to edit the wavefiles to ensure smooth continuity from the end of one wavefile to the beginning of the next when splicing them together to create prompts⁵. To as great an extent as possible, the prototypes shared wavefiles.

We ran the study to obtain data regarding the participants' ability to correctly obtain the appropriate conversion rates and conversion amounts, and to get information about the problems users encountered using these speech interface prototypes. We also wanted to obtain satisfaction ratings and rankings of the prototypes, and to compare user ratings of the recorded prompts with baseline TTS ratings obtained in a separate experiment (Lewis, 2000).

³ Earlier pre-testing with a full-duplex system (allowing barge-in) found that for this application, barge-in resulted in the well-known usability problem of the 'stuttering effect' (Balentine and Morgan, 1999). For this reason, we changed the systems to half-duplex.

⁴ SoundForge is a trademark or registered trademark of the Sonic Foundry, Inc.

⁵ Smoothing the splice points takes a lot of work, so it typically occurs only for an application that is about to go into actual use – not for prototypes.

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Method

Participants

Six people (four males and two females, all employees of a temporary employment agency) participated, using each prototype to complete two conversion tasks. The participants had no prior exposure to the prototypes. Five of the six participants had no experience using telephony products with speech user interfaces, although one participant (P6) had 5-10 exposures. Two of the participants had previous experience converting foreign currency. Four of the participants were age 20-29, one was 40-49, and one was over 59 years of age. All of the participants had at least some college education and most had a bachelor's degree or higher level of education. Refer to Appendix A for more specific descriptions of the individual participants' demographics.

Apparatus

The prototypes were Rexx code that made use of the ViaVoice⁶ Telephony Developer's Toolkit⁷. The prototypes were on local telephony servers, activated by calling specific phone numbers. The acoustic model for speech recognition was the ViaVoice speaker independent model for U.S. English telephony. We used a Hello Direct Universal Telephone Recorder Model TDI-5 attached to an Olympus⁸ Model DS-150 portable digital recorder to record the user-system interactions.

Procedure

Each participant completed a non-disclosure statement (including permission to record the interactions) and provided demographic information. The participants received a briefing on the basic procedure and explanations of the scenarios. The two scenarios (see Appendix B) were identical for each prototype. Participants used the three prototypes in a fully counterbalanced experimental design. The first scenario required the participant to change 500 German marks into Australian dollars. In the second scenario participants determined how many Australian dollars they needed to acquire 10,000 Japanese yen.

Thus, the two tasks required participants to convert currency in both directions. For example, to correctly complete the first task with prototype A, a participant should choose to sell the German marks. During the second task, a participant should choose to buy the Japanese yen. For both tasks the participants' goal was to obtain the correct conversion rate and correct conversion amount. The participants also made an effort to complete both tasks in a single phone call to each prototype. The participants were to complete the six tasks (2 tasks x 3 prototypes) and note the requested rate and amount on an answer sheet. The participants provided an overall satisfaction rating for each prototype (using a 10-point scale). After using all three prototypes, they ranked the prototypes from most- to

⁶ ViaVoice is a trademark or registered trademark of International Business Machines Corp.

⁷ The developers of the prototypes were Joe Simone and Mariusz Bogacz.

⁸ Olympus is a trademark or registered trademark of Olympus America, Inc.

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least-preferred. They also completed the Mean Opinion Scale (MOS), a questionnaire designed for the evaluation of the quality of artificial and recorded speech (Salza, Foti, Nebia, and Oreglia, 1996).

Results

Task Completion

The participants' ability to use the prototypes to obtain the correct conversion rate and the correct conversion amount for each task was of primary importance. Table 1 illustrates the number of participants that obtained the correct conversion rate and correct conversion amount, regardless of the number of attempts.

Table 1. Total number of participants (N=6) that obtained the correct conversion rate and correct conversion amount, collapsed over the number of attempts.

	Prototype					
	A		B		C	
	Correct RATE	Correct AMOUNT	Correct RATE	Correct AMOUNT	Correct RATE	Correct AMOUNT
Task 1	4	4	2	2	1	5
Task 2	4	4	4	5	6	2
Mean	4	4	3	3.5	3.5	3.5
Standard Deviation	0.00	0.00	1.41	2.12	3.54	2.12

Figure 1 (corresponding to Table 1) graphically represents the number of correct rates (CR) and correct amounts (CA) obtained for Task 1 (T1) and Task 2 (T2) across prototypes.

Figure 1. Overall task completion results

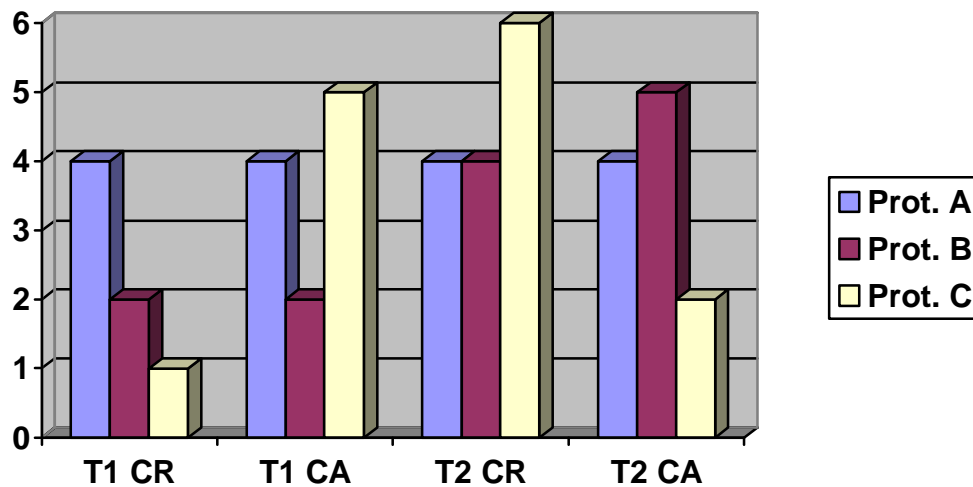


Table 2 summarizes the problems that participants experienced when completing the tasks.

Table 2. Summary of errors resulting in incorrect conversion rates or amounts.

	Prototype					
	A		B		C	
	RATE Errors	AMOUNT Errors	RATE Errors	AMOUNT Errors	RATE Errors	AMOUNT Errors
Task 1	TE, DE	RE, DE	4 - DE	4 - DE	3-DE, 2-TE	DE
Task 2	2 - DE	2 - DE	DE, TE	DE	None	2-RE, TE, OOG
<i>TE = Transcription Error, DE = Direction Error, RE = System Recognition Error, OOG = Out Of Grammar command</i>						

The categories for the usability errors were:

- a. Transcription error (TE) - Transcription errors occurred while transferring accurate and appropriate information presented by the prototype to the answer sheet.
- b. Direction error (DE) - Direction errors occurred when a participant converted currency rates or amounts in the wrong direction. For example, using prototype B, the participant might have converted “to” a foreign currency when it was appropriate to convert “from” a foreign currency.
- c. Recognition error (RE) - Recognition errors arose when the system did not accurately recognize correct input from the user. For example, the system might have interpreted “One-hundred” as “One-hundred-and-eight”.
- d. Out-of-grammar (OOG) utterances – Out-of-grammar errors came about when a user provided input that the prototype could not interpret. For example, the prototypes were not able to recognize phrases such as, “I want to convert to Japanese yen”.

Table 2 shows that direction errors (DE) were the most prevalent type of error across all prototypes. For prototypes A and B, conversion rate direction errors resulted when participants issued the wrong command during the prompt to “buy or sell foreign currency” (Prototype A) or to “convert to or from foreign currency” (Prototype B). Because prototype C converted the rates and amounts in both directions, participants’ direction errors were the result of misinterpreting the information presented by the system.

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(For more details about the problems that users experienced with the prototypes, see Appendix C. Appendix C contains six spreadsheets that identify the specific errors that participants committed during Task 1 and Task 2 for each prototype. The numbers in each chart identify (by participant number) which participant committed an error, and at what point during the transaction the error transpired.)

Tables 3 and 4 show the completion times and the successful completion rates for the participants' first attempt for the tasks using each prototype. Table 3 provides data for Task 1 and Table 4 provides data for Task 2. For these analyses, task completion was considered successful if the participant interacted with the prototype such that the prototype supplied the correct conversion rate and supplied the correct conversion amount (without regard to whether the participant transcribed or appeared to interpret the supplied information properly).

Table 3. Task 1 first-attempt completion times and successful completion rates.

Participant	System A - Buy/Sell		System B - To/From		System C - Both Directions	
	Task 1 - German Marks		Task 1 - German Marks		Task 1 - German Marks	
	Time First Attempt	Successful (0=No, 1=Yes)	Time First Attempt	Successful (0=No, 1=Yes)	Time First Attempt	Successful (0=No, 1=Yes)
P1	1:22	1	:42	0	1:24	1
P2	1:23	0	1:18	0	1:40	1
P3	1:55	1	1:15	0	1:36	1
P4	1:21	0	1:24	0	1:40	0
P5	1:25	0	1:12	1	1:29	0
P6	1:10	1	1:13	1	1:24	1
Mean	1:26	0.5	1:16	0.33	1:32	0.67
Standard Deviation	0:15		0:04		0:07	

Table 4. Task 2 first-attempt completion times and successful completion rates.

Participant	<u>System A - Buy/Sell</u>		<u>System B - To/From</u>		<u>System C - Both Directions</u>	
	Task 2 - Japanese Yen		Task 2 - Japanese Yen		Task 2 - Japanese Yen	
	Time First Attempt	Successful (0=No, 1=Yes)	Time First Attempt	Successful (0=No, 1=Yes)	Time First Attempt	Successful (0=No, 1=Yes)
P1	2:05	0	1:37	1	1:31	0
P2	:55	0	:58	1	1:30	1
P3	:58	1	1:04	1	1:28	0
P4	:51	0	1:08	0	1:26	1
P5	1:06	1	1:16	1	1:10	0
P6	:59	1	:57	1	2:55	0
Mean	1:35	0.50	1:16	0.83	1:40	0.33
Standard Deviation	0:41		0:14		0:37	

Turn-Taking Errors

Participants in this study experienced two different types of turn-taking errors – Spoke-Too-Soon (STS) and Spoke-Way-Too-Soon (SWTS). For both types of errors, the user began speaking before the beep. If the user continued speaking through the beep and into the recognition window, the error was STS. If the user finished speaking before the beep, the error was SWTS. It is important to make this distinction because it is possible for a speech recognition system to recognize the occurrence of an STS error by detecting speech energy at the onset of the recognition window (Balentine and Morgan, 1999). It is, however, not possible to detect the occurrence of an SWTS error.

Figure 2 presents an example of an STS error. Where the figure shows the STS error, the user's speech clearly begins before and continues through the beep. For comparison, the figure also shows a normal beep.

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Figure 2. STS Error

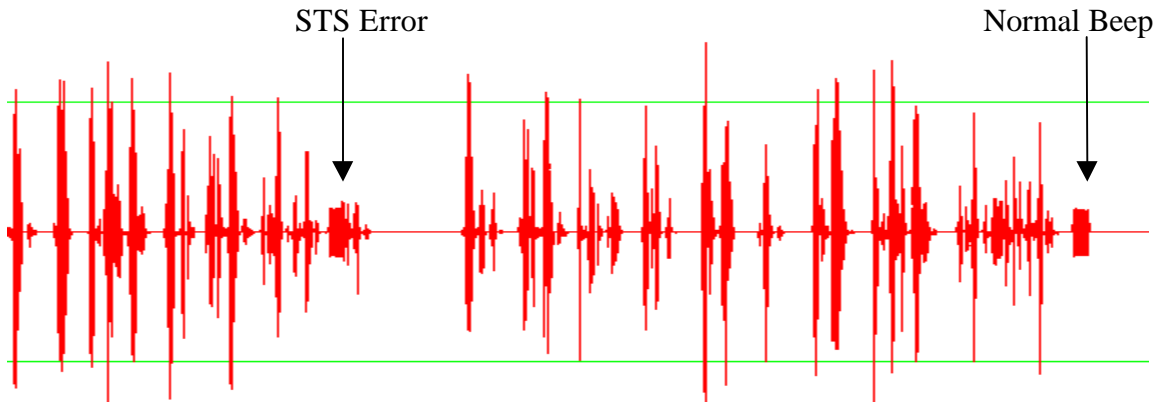
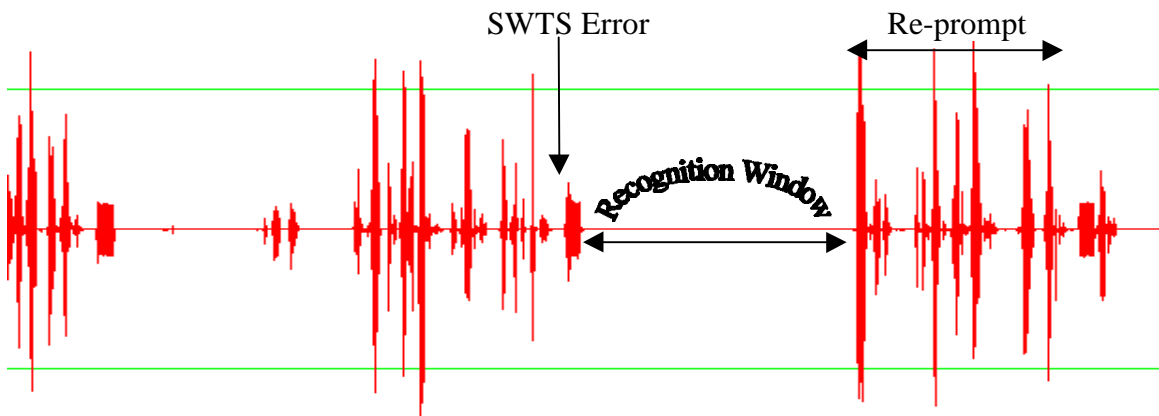


Figure 3 presents an example of an SWTS error, which shows that the participants' speech input occurred before and during the beep. However, no input occurred during the recognition window. This caused the system to produce a silence timeout, which resulted in the presentation of a self-revealing help prompt.

Figure 3. SWTS Error



Of the six participants, two experienced no turn-taking errors on their first attempt to complete the tasks, two experienced one each, one experienced three, and one experienced five. Table 5 shows an analysis of the frequency of occurrence of these turn-taking errors in the first attempt at task completion, collapsed across task and prototype and divided by the number of opportunities to make a turn-taking error. (See Appendix E for more detailed data.) The mean percentage of STS errors was 3.7%, and we can be 90% confident that the true mean is no greater than 7.6%. The mean percentage of SWTS errors was 2.6%, and we can be 90% confident that the true mean is no greater than 6.3%. For these types of turn-taking errors, the mean percentage was 6.3%, and we can be 90% confident that the true mean is no greater than 12.2%.

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Table 5. Frequency of first-try turn-taking errors

Participant	%STS	%SWTS	%Both
1	7.4	11.1	18.5
2	0.0	0.0	0.0
3	0.0	0.0	0.0
4	3.7	0.0	3.7
5	11.1	0.0	11.1
6	0.0	4.3	4.3
<i>Mean</i>	3.7	2.6	6.3
<i>Std Dev</i>	4.68	4.53	7.24
<i>Count</i>	6	6	6
<i>sem</i>	1.91	1.85	2.96
<i>df</i>	5	5	5
<i>crit-t</i>	2.015	2.015	2.015
<i>90% CI delta</i>	3.9	3.7	6.0
<i>Upper</i>	7.6	6.3	12.2
<i>Mean</i>	3.7	2.6	6.3
<i>Lower</i>	0.0	0.0	0.3

User Preferences

The participants ranked the Currency Converter prototypes, with 1 being the most preferred and 3 being the least preferred. Overall, the participants ranked prototype A (Buy/Sell) as the most preferred with an average rating of 1.33. Prototype B (To/From) was next with an average rating of 1.83. Prototype C (Both Directions) was the least preferred with an average rating of 2.83. A Friedman rank-sum test indicated that there was a significant preference difference among prototypes ($\chi^2(2) = 7.0, p = .03$). Multiple comparisons based on Friedman rank-sums indicated that participants significantly preferred prototype A to prototype C ($p < .05$), and marginally preferred Prototype B over prototype C ($p < .20$).

User Rating of Speech Output

Lewis (2000) provided an analysis⁹ of Mean Opinion Scale (MOS) ratings (Salza et al., 1996) for a number of competitive formant-synthesis TTS systems using varied types of test texts. The no-mental-effort (NME) text type was the most similar to the speech user interface prompts used in these prototypes (and resulted in the best ratings in Lewis, 2000). Table 6 shows the mean data from Lewis (2000) for the best-rated TTS system and the MOS ratings from this experiment, along with t-tests for each item of the MOS. (See Appendix F for the raw data and the exact wording for the seven MOS items.)

⁹ Based on data collected by Eric Suberville.

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Table 6. MOS ratings for high-quality TTS and this experiment's wavefiles (larger numbers indicate better ratings).

System	Global	Listen	Comp	Artic	Pron	Rate	Pleasant
<i>TTS</i>	3.1	4.5	4.6	3.9	4.1	4.7	2.9
<i>Wave</i>	4.5	4.5	4.7	4.5	4.7	4.3	4.3
<i>t</i>	2.812	0.099	0.228	1.705	1.099	1.442	3.661
<i>df</i>	19	19	19	19	19	19	19
<i>p</i>	0.011	0.922	0.822	0.104	0.285	0.166	0.002

Key: Global: Global Impression
Listen: Listening Effort
Comp: Comprehension Problems
Artic: Speech Sound Articulation
Pron: Pronunciation
Rate: Speaking Rate
Pleas: Voice Pleasantness

An analysis of variance indicated a significant main effect of system ($F(1,19)=3.1, p=.10$), a highly significant main effect of item ($F(6,114)=8.1, p=.0000003$), and a highly significant system by item interaction ($F(6,114)=6.5, p=.000006$). The *t*-tests in Table 5 indicate that the source of the significant interaction is due to system differences for Global Impression and Voice Pleasantness¹⁰.

It is important to keep in mind that this comparison uses data from different experiments with different protocols from different groups of users exposed to different types of text. So, it by no means proves that wave files assembled with suboptimal splicing necessarily get better user ratings than high-quality formant-synthesized TTS. The outcome of this analysis is, however, consistent with the observation that users tend to prefer recorded speech to formant-synthesized speech.

¹⁰ To keep the overall Type I error rate for this comparison to no greater than .20, the Bonferroni criterion for significance for a single *t*-test in the group of seven *t*-tests is .03 (.20/7). The observed significance levels (*p*) for tests meeting this criterion appear bolded in Table 5.

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Recommendations

High Priority

Recommendation 1: Present the instruction, “Please speak to the system after the beep” when participants produce a Spoke-Too-Soon (STS) error.

Three of the six participants produced spoke-too-soon (STS) errors. STS errors occurred when users spoke *during and after the beep*. Thus, the system captured only a portion of the utterance in the recognition window. For these prototypes, STS errors resulted in substitution (OOG) errors or the presentation of self-revealing help prompts (without the instruction to speak after the beep). The system should detect when speech input occurs during the beep, triggering a special STS prompt to “Speak to the system after the beep.”

Recommendation 2: Add the instruction, “Speak to the system after the beep.” to self-revealing help prompts triggered by a silence timeout.

Two of the six participants produced spoke-way-too-soon (SWTS) errors. An SWTS error arose when users *spoke before and/or during the beep, but no speech occurred during the recognition window*. In these prototypes, if the user spoke during the prompt, finished speaking before the beep began (SWTS error), and didn’t speak again, the system produced a silence timeout. Therefore, it is appropriate to handle silence timeout errors as possible SWTS errors, incorporating an instruction to speak after the beep into the self-revealing help prompts presented for silence timeouts. For example, “Please say either Buy or Sell *after the beep*.” This is especially important for longer system prompts because shorter system prompts provide little opportunity for a user to commit a SWTS error.

Recommendation 3: Present the “Please speak to the system after the beep” prompt at the end of the introduction, just before requesting the initial input from the user.

Of the four participants that committed STS or SWTS errors, two produced several of these types of error. This suggests that those participants did not grasp the portion of the introduction that instructed them to speak after the beep. In accordance with Balentine and Morgan (1999 – *Guideline 2.3.1.2*), the prompt should place the key information just before the user is supposed to begin speaking. Thus, this prompt should appear just before the prompt to speak, increasing the likelihood that users would wait for the beep before speaking.

Recommendation 4: Aggressively trim silence from the end of wavefiles to prevent time lapses between the end of the prompt and the presentation of the beep.

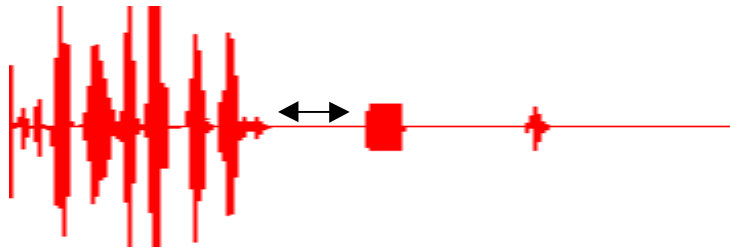
There were occasions when the beep did not occur for more than a full second after the end of the prompt. The beep should follow “immediately” after the prompt (Balentine and Morgan, 1999 – *Guideline 2.1.4.2*). Balentine and Morgan (1999) suggest that “dovetailing” (a new speaker beginning to talk just as another stops) is a natural

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occurrence in normal speech and in speech-enabled applications. They also suggest that STS errors “can be expected to increase as users become expert and comfortable with the application.” (p. 123)

Figure 4 provides an example (from the raw data of this experiment) in which 1.2 seconds elapsed between the end of the prompt and start of the beep. It is likely that users would interpret this type of lengthy time gap as a turn taking cue, causing them to speak before the beep.

Figure 4. Elapsed time of 1.2 seconds between prompt and beep.



Aggressive trimming combined with the implementation of Recommendations 1, 2 and 3, should eliminate (or at least minimize) the occurrence of STS and SWTS errors.

Recommendation 5: Provide a tutorial that explains the importance of converting currency in the correct direction.

The prevalence of direction errors (with all prototypes) suggests that participants might have been confused regarding how to convert currency in the proper direction or were unaware of the importance of the conversion direction. As mentioned earlier in this report, the direction of the conversion directly affects the conversion rate and subsequent conversion amounts. In other words, conversion rates for buying and selling the same foreign currency are not symmetrical. The current prototypes do not inform the user that exchange rates differ based upon the direction of conversion. Due to the number of directional errors during conversion, it appears prudent to provide users with more information regarding its importance for accurate conversions. Prototype C provides conversion rates and amounts in both directions, yet four participants still produced direction errors. The majority of these were conversion rate direction errors. In other words, the participant heard both conversion rates and chose to write the wrong one. Therefore, the availability of a tutorial might be beneficial for all prototypes.¹¹

¹¹ Getting this information to the user appears to be so important that we considered adding a sentence to the introduction (just before the “Wait for the beep” sentence) that said, “The conversion rates for buying and selling are different.” This would, however, make the introduction 15 syllables longer. Anyone building a publicly available currency converter in which the conversion rates are asymmetrical should consider including this sentence in the introduction.

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Medium Priority

Recommendation 6: Remove the word “always” from the introductory phrase, “The options ... <list>... are always available”.

The phrase, “the options... <list>... are always available” implies that the system is full duplex with the capacity for barge-in. During the experiment, several users issued the commands ‘repeat’ or ‘start over’ in the middle of a prompt or during conversion information. Therefore, remove the word “always” from this phrase so users will be less likely to believe that the system is full duplex.

Recommendation 7: Remove “Help” from the options list in the introduction.

The prompts associated with the “Help” command were the same as the self-revealing help prompts produced when the system detected OOG errors or silence timeouts. Typically, one of these errors would occur when users were confused, resulting in the presentation of the same information that the “Help” command would elicit. It is likely that users would say the word “help” intuitively. Therefore, it should be acceptable to remove the “Help” command from the introduction, while keeping it available in the always-active grammar. Removing “Help” from the list reduces the number of options users must commit to memory while listening to the prompt, and also makes the prompt shorter.

Recommendation 8: Remove “Cancel” from the options list in the introduction.

The “Cancel” command provided a way for users to go back to the previous prompt and change the input. In these prototypes, however, if the user wanted to alter the previous input, the “Start Over” command was also available. Using “Start Over” would be an acceptable strategy for changing the input due to the relatively small number of inputs required by the user to complete a transaction (either 2 or 3 inputs, depending upon the prototype). Removing “Cancel” from the list reduces the number of options users must commit to memory while listening to the prompt, and also makes the prompt shorter. Even though “Cancel” would no longer be in the options list in the introduction, it would be appropriate to leave it in the always-active grammar.

Recommendation 9: Limit the length of the conversion rate to five numbers to the right of the decimal point.

Prototype C stated that the conversion rate from Japanese yen to Australian dollars was 0.0158307127 Australian dollars per Japanese yen. The prototypes were capable of converting amounts no larger than 999,999 currency units. Therefore, conversion rates containing more than five digits to the right of the decimal place were unnecessary, extended the length of the transaction, and made transcription errors more likely. Should a user want to convert even a very large amount of currency, such as 100,000 Japanese yen into Australian dollars, the conversion rate of 0.01583 is sufficient to convert to ‘whole

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dollars' (at that rate, 100,000 Japanese yen converts to 1583 Australian dollars). It is unlikely that users would be overly concerned with conversion amounts less than a full unit of currency (for example, the difference between \$1583 and \$1583.07 is negligible). If, for some reason (legal reasons, bank policy, etc.), truncating the currency to whole amounts is not feasible, then the required conversion rate only needs seven digits to the right of the decimal point.

Low Priority

Recommendation 10: Remove from the introduction the phrase, "This system provides exchange rates between Australian dollars and the major currencies of the world."

It is probably not necessary to emphasize that the system converts between Australian dollars and other currencies because Australian dollars are always the default currency in the conversion rates and amounts provided. This would have the benefit of reducing the length of the introduction.

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Appendix A. Participant Demographics

Participant	Gender	Age	Educ. Level	Telephony Experience	Currency Conversion Experience
1	M	40-49	BA	None	Yes
2	F	20-29	Adv. Degree	None	No
3	F	20-29	Some College	None	No
4	M	20-29	Some College	None	No
5	M	>59	BA+	None	Yes
6	M	20-29	BA	5-10 times	No

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Appendix B. Currency Converter Task Scenarios

Participants attempted these two task scenarios with each prototype.

Imagine you live in Australia. You want to call the Aussie Bank automated currency converter at **9-615-XXXX** to get some currency exchange information. Please use the automated currency converter to get the following information, for scenario's #1 and #2, in a single phone call.

1.) You just came back from Germany, and have 100 German marks that you want to convert into Australian dollars.

A. What is the exchange rate?

B. How many dollars will you get?

2.) You are planning a trip to Japan and want to bring 10,000 yen with you for expenses.

A. What is the exchange rate?

B. How many dollars must you spend?

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Appendix C. Error Identification Charts

The following six charts identify, by participant, errors that occurred during participants' *first attempt* at tasks 1 and 2. The charts also indicate at what point during the transaction the error(s) occurred. For more specific information, see Appendix D, which contains detailed transcripts of each participant's transactions for each task across prototypes.

Errors identified in these spreadsheets include:

- a) Silence timeouts
- b) Out of grammar (OOG) utterances
- c) Spoke-too-soon (STS) errors¹²
- d) Spoke-way-too-soon (SWTS) errors¹³
- e) Re-prompts
- f) Direction errors
- g) Recognition errors
- h) 'Booted-out' of the system.

¹² A spoke-too-soon error occurs when a participant begins speaking before the tone, and the speech continues past the end of the tone into the recognition window.

¹³ A spoke-way-too-soon error occurs when a participant begins speaking before the tone, and the speech ends before the end of the tone.

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Part 1 of 6

Prototype A - (Buy or Sell) Task 1		Silence Time out	OOG	STS	SWTS	Prompted	Dir. Error	Rec. Error	Booted Out
Speaking	Spoken								
System	<Intro>								
System	<u>Do you want to Buy or Sell Foreign Currency?</u>								
User	Sell	2,4	5				3		
<i>Prompt</i>	<i>Please say either Buy or Sell</i>					2,4,5			
User	Sell (prompted)						4,5		
System	<u>Sell currency from which country?</u>								
User	Germany						3,5		
<i>Prompt</i>	<i>For example to sell currency from Germany say Germany</i>								
User	Germany (prompted)								
System	<u>Our current conversion rate is X German Marks per Aus \$</u>								
System	<u>How many German Marks would you like to Sell?</u>								
User	100		3,5					2	
<i>Prompt</i>	<i>For example to sell 100 German Marks say 100</i>								
User	100 (prompted)								
System	<u>100 German Marks converts to X Aus Dollars</u>								
System	<u>Would you like to do another transaction?</u>								
User	Yes								
<i>Prompt</i>	<i>Please say either Yes or No</i>								
User	Yes (prompted)								

Unclassified

Part 2 of 6

Prototype A - (Buy or Sell) Task 2		Silence Time Out	OOG	STS	SWTS	Prompted	Dir. Error	Rec. Error	Booted out
Speaking	Spoken								
System	<Intro>								
System	Do you want to Buy or Sell Foreign Currency?								
User	Buy		1				2,4		
Prompt	Please say either Buy or Sell					1			
User	Buy (prompted)								
System	Buy currency from which country?								
User	Japan			5	1				
Prompt	For example to buy currency from Germany say Germany					1,5			
User	Japan (prompted)		1						
System	Our current conversion rate is X Japanese Yen per Aus \$							1	
System	How many Japanese Yen would you like to Buy?							1	
User	10,000		1						
Prompt	For example to buy 100 Japanese Yen say 100							1	
User	10,000 (prompted)								
System	10,000 Japanese Yen converts to X Aus Dollars								
System	Would you like to do another transaction?								
User	No		1,6	5					
Prompt	Please say either Yes or No					1,5,6			
User	No (prompted)				1				1

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Part 3 of 6

Prototype B - (To or From) Task 1		Silence Time out	OOG	STS	SWTS	Prompted	Dir. Error	Rec. Error	Booted Out
Speaking	Spoken								
System	<Intro>								
System	Do you want to convert to or from foreign currency?								
User	From	4	1				2,3		
Prompt	Please say either To or From					1,4			
User	From (prompted)			1			1,4		1
System	Convert currency from which country?								
User	Germany								
Prompt	For example to convert German currency say Germany								
User	Germany (prompted)								
System	Our current conversion rate is X German Marks per Aus \$								
System	How many German Marks would you like to convert?								
User	100								
Prompt	For example to convert 100 German Marks say 100								
User	100 (prompted)								
System	100 German Marks converts to X Aus Dollars								
System	Would you like to do another transaction?								
User	Yes								
Prompt	Please say either Yes or No								
User	Yes (prompted)								

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Part 4 of 6

Prototype B - (To or From) Task 2		Silence Time out	OOG	STS	SWTS	Prompted	Dir. Error	Rec. Error	Booted Out
Speaking	Spoken								
System	<Intro>								
System	Do you want to convert to or from foreign currency?								
User	To	4							
Prompt	Please say either To or From					4			
User	To (prompted)						4		
System	Convert Aus \$s to currency of which country?								
User	Japan								
Prompt	For example to convert German currency say Germany								
User	Japan (prompted)								
System	Our current conversion rate is X Japanese Yen per Aus \$								
System	How many Japanese Yen would you like to convert?								
User	10,000								
Prompt	For example to convert 100 Japanese Yen say 100								
User	10,000 (prompted)								
System	100 Japanese Yen converts to X Aus Dollars								
System	Would you like to do another transaction?								
User	Yes	4		1					
Prompt	Please say either Yes or No					1,4			
User	Yes (prompted)				1				1

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Part 5 of 6

Prototype C - (Both Dir.) Task 1		Silence Time out	OOG	STS	SWTS	Prompted	Dir. Error	Rec. Error	Booted Out
Speaking	Spoken								
System	<Intro>								
System	Which country?								
User	Germany								
Prompt	For example to convert German currency say Germany								
User	Germany (prompted)								
System	<u>We currently convert to German Marks at the rate of X German Marks per Aus \$, and from German Marks at the rate of X Aus \$\$ per German Mark.</u>								
System	What amount would you like to convert?								
User	100		5	4					
Prompt	For example to convert 100 Australian \$\$s say 100 Australian \$s.					4,5			
User	100 (prompted)	5					4		5
System	<u>100 German Marks converts to X Aus Dollars and 100 Aus \$\$ converts to X German Marks.</u>								
System	Would you like to do another transaction?								
User	Yes								
Prompt	Please say either Yes or No								
User	Yes (prompted)								

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Part 6 of 6

Prototype C - (Both Dir.) Task 2		Silence Time out	OOG	STS	SWTS	Prompted	Dir. Error	Rec. Error	Booted Out
Speaking	Spoken								
System	<Intro>								
System	Which country?								
User	Japan			5				5	
Prompt	For example to convert German currency say Germany								
User	Japan (prompted)								
System	We currently convert to Japanese Yen at the rate of X Japanese Yen per Aus \$, and from Japanese Yen at the rate of X Aus \$s per Japanese Yen.								
System	What amount would you like to convert?								
User	10,000		5					1,6	
Prompt	For example to convert 100 Australian \$s say 100 Australian \$s.					5			
User	10,000 (prompted)		5						5
System	100 Japanese Yen converts to X Aus Dollars and 100 Aus \$s converts to X Japanese Yen.								
System	Would you like to do another transaction?								
User	No				6				
Prompt	Please say either Yes or No								
User	No (prompted)								

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Appendix D. Task Transcripts

The following pages contain the transcripts for each participant's attempt(s) to complete the two tasks using each prototype.¹⁴

¹⁴ Prototype presentation orders were fully counterbalanced across participants.

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Participant 1 - Prototype A

Participant 1 (Prototype A)			
Speaking	Spoken	Comments	Time
Task 1	Task 1	Task 1	
System	<Intro>		:44
System	Do you want to Buy or Sell Foreign Currency?		
User	I want to sell		
System	Sell currency from which country?		
User	From Germany		
System	Our current conversion rate is X German Marks per Aus \$		
System	How many German Marks would you like to Sell?		
User	100	Spoken as "a hundred" yet system recognizes the user input properly.	
System	100 German Marks converts to X Aus Dollars		
System	Would you like to do another transaction?		
User	Um...not at this time		
System	Thank you for calling, Goodbye	User hangs up and redials for task 2	2:06
Task 2	Task 2	Task 2	
	Attempt #1	Attempt #1	
System	<Intro>		2:39
System	Do you want to Buy or Sell Foreign Currency?		
User	I want to, ah..., I want the exchange rate		
System	Please say either Buy or Sell		
User	Ah, buy		
System	Buy currency from which country?		
User	Japan	Spoke Way Too Soon <SWTS>	
System	For example to buy currency from Germany, say Germany.		
User	I wanna buy Japan		
System	Our current conversion rate is X Dutch Guilders per Aus \$, How many Dutch Guilders would you like to buy?	System did not recognized the country from user input	
User	Ah, I want to bring 10,000 Yen	Participant tries to recover	
System	110,010 Dutch Guilders converts to X Aus \$, would you like to do another transaction.	System misinterprets user input	
User	Um.....	Participant seems unsure as to how to proceed	
System	Please say either Yes or No		
User	Yes	Spoke Way Too Soon <SWTS>	
System	Sorry for the confusion please call back later and try again, Good bye.	System hangs up/disconnects	4:44
	Attempt #2	Attempt #2	
System	<Intro>		5:15
System	Please say Buy or Sell		
User	I want to buy, um..., foreign currency		
System	Buy currency from which country?		
User	Ah.. from Japan		
System	Our Current conversion rate is X Japanese Yen per Aus \$, How many Japanese Yen would you like to buy?		
User	Ten Thousand		
System	10000 Japanese Yen converts to X Aus dollars		
System	Would you like to do another transaction?		
User	No		
System	Thank you for calling, Goodbye		6:31

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Participant 2 – Prototype A

Participant 2 (Prototype A)			
Speaking	Spoken	Comments	Time
Task 1	Task 1	Task 1	
System	<Intro>		:54
System	Do you want to Buy or Sell Foreign Currency?		
User	Silence time out	... user not sure whether she wants to buy or sell	
System	Please say either Buy or Sell		
User	Sell		
System	Sell currency from which country?		
User	Germany		
System	Our current conversion rate is X German Marks per Aus \$		
System	How many German Marks would you like to Sell?		
User	100	100 pronounced as "one hundred"	
System	108 German Marks converts to X Aus Dollars	100 interpreted as 108, however, the user did not catch the erroneous feedback and noted an incorrect conversion amount.	
System	Would you like to do another transaction?		
User	Yes		2:17
Task 2	Task 2	Task 2	
System	Do you want to Buy or Sell Foreign Currency?		2:18
User	Sell	Direction of conversion is wrong for this scenario resulting in an erroneous conversion rate and amount.	
System	Sell currency from which country?		
User	Japan		
System	Our current conversion rate is X Japanese Yen per Aus \$		
System	How many Japanese Yen would you like to sell?		
User	Ten Thousand		
System	10000 Japanese Yen converts to X Aus dollars		
System	Would you like to do another transaction?		
User	No		
System	Thank you for calling, Goodbye		3:13

Unclassified

Participant 3 – Prototype A

Participant 3 (Prototype A)			
Speaking	Spoken	Comments	Time
Task 1	Task 1	Task 1	
System	<Intro>		3:12
System	Do you want to Buy or Sell Foreign Currency?		
User	Buy		
System	Buy currency from which country?		
User	Australia	User converting in wrong direction.	
System	Our current conversion rate is 1 Aus \$ per Aus \$		
System	How many Australian dollars would you like to buy?		
User	None	User realized Error	
System	Nine Aus \$s converts to Ten Aus \$s	???? Nine Aus\$ = Ten Aus \$????	
System	Would you like to do another transaction?		
User	Yes		4:18
System	Do you want to Buy or Sell Foreign Currency?		4:19
User	Sell		
System	Sell currency from which country?		
User	Germany		
System	Our current conversion rate is X German Marks per Aus \$		
System	How many German Marks would you like to Sell?		
User	100		
System	100 German Marks converts to X Aus Dollars		
System	Would you like to do another transaction?		
User	Yes		5:07
Task 2	Task 2	Task 2	
System	Do you want to Buy or Sell Foreign Currency?		5:09
User	Buy		
System	Buy currency from which country?		
User	Japan		
System	Our current conversion rate is X Japanese Yen per Aus \$		
System	How many Japanese Yen would you like to buy?		
User	10,000		
System	10000 Japanese Yen converts to X Aus dollars		
System	Would you like to do another transaction?		
User	No		
System	Thank you for calling, Goodbye		6:07

Unclassified

Participant 4 – Prototype A

Participant 4 (Prototype A)			
Speaking	Spoken	Comments	Time
Task 1	Task 1	Task 1	
System	<Intro>		6:53
System	Do you want to Buy or Sell Foreign Currency?		
User	<Silence>	Silence time out - system reprompts	
System	Please say either Buy or Sell		
User	Buy?	User does not seem sure whether he wants to buy or sell. DE - Should have said "Sell"	
System	Buy currency from which country?		
User	German... Germa..Germany	Although user stumbles the system responds properly.	
System	Our current conversion rate is X German Marks per Aus \$		
System	How many German Marks would you like to Buy?		
User	100		
System	100 German Marks converts to X Aus Dollars		
System	Would you like to do another transaction?		
User	Yes		8:14
Task 2	Task 2	Task 2	
System	Do you want to Buy or Sell Foreign Currency?		8:15
User	Sell	DE - Converting in wrong direction, should have said "Buy" for this scenario.	
System	Sell currency from which country?		
User	Japan		
System	Our current conversion rate is X Japanese Yen per Aus \$		
System	How many Japanese Yen would you like to buy?		
User	10,000		
System	10000 Japanese Yen converts to X Aus dollars		
System	Would you like to do another transaction?		
User	<No verbal response>	User hangs up	9:06
		<i>Although the user ranked this system the highest both transactions were completed incorrectly.</i>	

Participant 5 – Prototype A

Participant 5 (Prototype A)			
Speaking	Spoken	Comments	Time
Task 1	Task 1	Task 1	
	Attempt 1	Attempt 1	
System	<Intro>		6:14
System	Do you want to Buy or Sell Foreign Currency?		
User	Um..convert		
System	Please say either Buy or Sell		
User	Buy		
System	Buy currency from which country?		
User	Australia	Confusion regarding the direction of conversion	
System	Our current conversion rate is 1 AUS \$ per Aus \$		
System	How many Australian \$ would you like to buy?		
User	I don't want Aust... I have a hundred marks..		
System	For example, to buy 100 Aus \$ say 100.		
User	<laughs nervously> I need...ya know ..this is wrong... I am going to hang up.	<Hangs up>	7:39
	Attempt 2	Attempt 2	
System	<Intro>		:00
System	Do you want to Buy or Sell Foreign Currency?		
User	Sell		
System	Sell currency from which country?		
User	Germany		
System	Our current conversion rate is X German Marks per Aus \$		
System	How many German Marks would you like to sell?		
User	100		
System	100 German Marks converts to X Aus \$'s		
System	Would you like to do another transaction?		
User	Yes		1:00
Task 2	Task 2	Task 2	
System	Do you want to Buy or Sell Foreign Currency?		1:01
User	Buy		
System	Buy currency from which country?		
User	Japan... Japan	<STS>	
System	For example, to buy currency from Germany say Germany.		
User	Japan		
System	Our current conversion rate is X Japanese Yen per Aus \$		
System	How many Japanese Yen would you like to buy?		
User	10,000		
System	10000 Japanese Yen converts to X Aus dollars		
System	Would you like to do another transaction?		
User	No	<STS>	
System	Please say either Yes or No		
User	No..no.	<Hangs up>	2:07

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Participant 6 – Prototype A

Participant 6 (Prototype A)			
Speaking	Spoken	Comments	Time
Task 1	Task 1	Task 1	7:10
System	<Intro>		
System	Do you want to Buy or Sell Foreign Currency?		
User	Sell		
System	Sell currency from which country?		
User	Germany		
System	Our current conversion rate is X German Marks per Aus \$		
System	How many German Marks would you like to Sell?		
User	100		
System	100 German Marks converts to X Aus Dollars		
System	Would you like to do another transaction?		
User	Yes		8:20
Task 2	Task 2	Task 2	8:21
System	Do you want to Buy or Sell Foreign Currency?		
User	Buy		
System	Buy currency from which country?		
User	Japan		
System	Our current conversion rate is X Japanese Yen per Aus \$		
System	How many Japanese Yen would you like to buy?		
User	10,000		
System	10000 Japanese Yen converts to X Aus dollars		
System	Would you like to do another transaction?		
User	No Thank You		
System	Please say Yes or No		
User	No		
System	Thank you for calling, Goodbye		9:20

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Participant 1 – Prototype B

Participant 1 (Prototype B)			
Speaking	Spoken	Comments	Time
Task 1	Task 1	Task 1	
	Attempt 1	Attempt 1	
System	<Intro>		7:36
System	Do you want to convert to or from foreign currency?		
User	I wanna convert ... to	Computer does not recognize command	
System	Please say either to or from		
User	To	Spoke Too Soon <STS>	
System	"Sorry for the confusion please call back later and try again, Good bye.	System disconnects	8:18
	Attempt 2	Attempt 2	
System	<Intro>		8:46
System	Do you want to convert to or from foreign currency?		
User	Convert to		
System	Convert AUS \$'s to currency of which country?		
User	Germany	Spoke Way Too Soon <SWTS>	
System	For example, to convert German currency, say Germany		
User	Germany		
System	Our current conversion rate is X German Marks per Aus \$		
System	How many German Marks would you like to convert?		
User	100	<STS> Started speaking "one hundred" before the beep prompt and the command ran during and after the beep resulting in the system interpreting the input as "nine hundred"	
System	900 German Marks converts to X Aus Dollars		
System	Would you like to do another transaction?		
User	Um.. Help	User confused at misinterpretation of currency amount and asks for help	
System	Please say either Yes or No		
User	No		
System	Thank you for calling Good Bye		10:27
	Attempt 3	Attempt 3	
System	<Intro>		11:22
System	Do you want to convert to or from foreign currency?		
User	To		
System	Convert AUS \$'s to currency of which country?		
User	Germany	Spoke Way Too Soon <SWTS>	
System	For example, to convert German currency, say Germany		
User	Germany	Spoke Too Soon <STS>	
System	"Sorry for the confusion please call back later and try again, Good bye.		12:16

	Attempt 4	Attempt 4	
System	<Intro>		12:42
System	Do you want to convert to or from foreign currency?		
User	To		
System	Convert AUS \$'s to currency of which country?		
User	Germany	Spoke Too Soon <STS>	
System	For example, to convert German currency, say Germany		
User	Germany		
System	Our current conversion rate is X German Marks per Aus \$		
System	How many German Marks would you like to convert?		
User	100		
System	100 German Marks converts to X AUS \$'s		
System	Would you like to do another transaction?		
User	Yes	Spoke Way Too Soon <SWTS>	
System	Please say either Yes or No		
User	Yes	Spoke Way Too Soon <SWTS>	
System	"Sorry for the confusion please call back later and try again, Good bye.	System disconnects	14:28
Task 2	Task 2	Task 2	
System	Do you want to convert to or from foreign currency?		14:47
User	I wanna convert to		
System	Convert Aus \$ to currency of which country?		
User	Japan		
System	Our current conversion rate is X Japanese Yen per Aus \$		
System	How many Japanese Yen would you like to convert?		
User	Ten Thousand		
System	10000 Japanese Yen converts to X Aus dollars		
System	Would you like to do another transaction?		16:02
User	Yes	Participant got the information desired but did not get it written down fast enough. Instead of using a "repeat" command he decided to try the entire task again. Also speaks too soon (STS) again in trying to do so.	
System	Please say either Yes or No		
User	Yes	Spoke Way Too Soon <SWTS>	
System	"Sorry for the confusion please call back later and try again, Good bye.		16:24
	The participant subsequently tried to repeat the task 3 more times and continued to speak during the prompt or during the beep. 2 SWTS's and 3 STS's. (At this point the participant is explicitly instructed to be sure and speak system commands "after" the beep!!)		16:45 - 17:31 18:02 - 18:49 19:15 - 19:45

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Participant 2 – Prototype B

Participant 2 (Prototype B)			
Speaking	Spoken	Comments	Time
Task 1	Task 1	Task 1	7:20
System	<Intro>		
System	Do you want to convert to or from foreign currency?		
User	To	Direction of conversion is wrong for this scenario resulting in an erroneous conversion rate and amount	
System	Convert AUS \$s to currency of which country?		
User	Germany		
System	Our current conversion rate is X German Marks per Aus \$		
System	How many German Marks would you like to convert?		
User	100		
System	100 German Marks converts to X Aus Dollars		
System	Would you like to do another transaction?		
User	Yes		8:38
Task 2	Task 2	Task 2	
System	Do you want to convert to or from foreign currency?		8:40
User	To		
System	Convert Aus \$ to currency of which country?		
User	Japan		
System	Our current conversion rate is X Japanese Yen per Aus \$		
System	How many Japanese Yen would you like to convert?		
User	Ten Thousand		
System	10000 Japanese Yen converts to X Aus dollars		
System	Would you like to do another transaction?		
User	No		
System	Thank you for calling, Goodbye		9:38

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Participant 3 – Prototype B

Participant 3 (Prototype B)			
Speaking	Spoken	Comments	Time
Task 1	Task 1	Task 1	
System	<Intro>		0:24
System	Do you want to convert to or from foreign currency?		
User	To	Used "to" instead of "from" ultimately resulting in an erroneous conversion rate and amount - direction error	
System	Convert currency from which country?		
User	German... Germany		
System	Our current conversion rate is X German Marks per Aus \$		
System	How many German Marks would you like to convert?		
User	100		
System	100 German Marks converts to X Aus Dollars		
System	Would you like to do another transaction?		
User	Yes		1:39
Task 2	Task 2	Task 2	
System	Do you want to convert to or from foreign currency?		1:41
User	To		
System	Convert Aus \$ to currency of which country?		
User	Japan		
System	Our current conversion rate is X Japanese Yen per Aus \$		
System	How many Japanese Yen would you like to convert?		
User	Ten Thousand		
System	10000 Japanese Yen converts to X Aus dollars		
System	Would you like to do another transaction?		
User	No		
System	Thank you for calling, Goodbye		2:45

Participant 4 – Prototype B

Participant 4 (Prototype B)			
Speaking	Spoken	Comments	Time
Task 1	Task 1	Task 1	:00
System	<Intro>		
System	Do you want to convert to or from foreign currency?		
Userto...	System timed out	
System	Please say either To or From		
User	To	Converting in wrong direction, should have said "From", therefore, he obtained a wrong conversion rate and amount.	
System	Convert Aus \$s to currency of which country?		
User	Germany		
System	Our current conversion rate is X German Marks per Aus \$		
System	How many German Marks would you like to convert?		
User	100		
System	100 German Marks converts to X Aus Dollars		
System	Would you like to do another transaction?		
User	Yes		1:24
Task 2	Task 2	Task 2	
System	Do you want to convert to or from foreign currency?		1:27
User	<Silence>	Silence time out - re-prompt	
System	Please say either To or From		
User	From	Converting in wrong direction, should have said "To", therefore, he obtained a wrong conversion rate and amount.	
System	Convert currency from which country?		
User	Japan		
System	Our current conversion rate is X Japanese Yen per Aus \$		
System	How many Japanese Yen would you like to convert?		
User	Ten Thousand		
System	10000 Japanese Yen converts to X Aus dollars		
System	Would you like to do another transaction?		
User	<Silence>	Silence time out - re-prompt	
System	Please say either Yes or No		
User	Yes	Says Yes to a new transaction, but knows he is done with both scenarios and hangs up.	2:35

Participant 5 – Prototype B

Participant 5 (Prototype B)			
Speaking	Spoken	Comments	Time
Task 1	Task 1	Task 1	
System	<Intro>		2:52
System	Do you want to convert to or from foreign currency?		
User	From		
System	Convert currency from which country?		
User	Germany		
System	Our current conversion rate is X German Marks per Aus \$		
System	How many German Marks would you like to convert?		
User	100		
System	100 German Marks converts to X Aus Dollars		
System	Would you like to do another transaction?		
User	Yes		4:04
Task 2	Task 2	Task 2	
System	Do you want to convert to or from foreign currency?		4:06
User	To		
System	Convert Aus \$ to currency of which country?		
User	Japan		
System	Our current conversion rate is X Japanese Yen per Aus \$		
System	How many Japanese Yen would you like to convert?		
User	Ten Thousand		
System	10000 Japanese Yen converts to X Aus dollars		
System	Would you like to do another transaction?		
User	Repeat		5:03
System	10,000 Japanese Yen converts to X Aus dollars		
System	Would you like to do another transaction?	Not sure what is happening here. The user obtained the information needed and noted it correctly but tries to start over	
User	Um..Start over		5:22
System	Please say either Yes or No		
User	Yes		
System	Do you want to convert to or from foreign currency?		
User	To		
System	Convert Aus \$ to currency of which country?		
User	Japan		
System	Our current conversion rate is X Japanese Yen per Aus \$		
System	How many Japanese Yen would you like to convert?		
User	Well this is not... I got what I needed..	<Hangs up>	6:09

Unclassified

Participant 6 – Prototype B

Participant 6 (Prototype B)			
Speaking	Spoken	Comments	Time
Task 1	Task 1	Task 1	4:44
System	<Intro>		
System	Do you want to convert to or from foreign currency?		
User	From		
System	Convert currency from which country?		
User	Germany		
System	Our current conversion rate is X German Marks per Aus \$		
System	How many Geman Marks would you like to convert?		
User	100		
System	100 German Marks converts to X Aus Dollars		
System	Would you like to do another transaction?		
User	Yes	Yes...<beep> Yes. <STS>	5:57
Task 2	Task 2	Task 2	5:59
System	Do you want to convert to or from foreign currency?		
User	To		
System	Convert Aus \$ to currency of which country?		
User	Japan		
System	Our current conversion rate is X Japanese Yen per Aus \$		
System	How many Japanese Yen would you like to convert?		
User	Ten Thousand		
System	10000 Japanese Yen converts to X Aus dollars		
System	Would you like to do another transaction?		
User	No		
System	Thank you for calling, Goodbye		6:56

Unclassified

Participant 1 – Prototype C

Participant 1 (Prototype C)			
Speaking	Spoken	Comments	Time
Task 1	Task 1	Task 1	
System	<Intro>		2:35
System	Which Country?		
User	Germany		
System	We currently convert to German Marks at the rate of X German Marks per Aus \$, and from German Marks at the rate of X Aus \$s per German Mark.		
System	What amount would you like to convert?		
User	100 German Marks		
System	100 German Marks converts to X Aus Dollars, and 100 Aus \$s converts to X German Marks.		
System	Would you like to do another transaction?		
User	Yes		3:59
Task 2	Task 2	Task 2	
System	Which Country?		4:01
User	Japan		
System	We currently convert to Japanese Yen at the rate of X Japanese Yen per Aus \$, and from Japanese Yen at the rate of X Aus \$s per Japanese Yen.		
System	What amount would you like to convert?		
User	10,000 Yen		
System	10,010 Japanese Yen converts to X Aus dollars, and 10,010 Aus \$ convert to X Japanese Yen	10,000 Japanese Yen interpreted as 10,010 (Yen and Ten are synonyms and therefore assumed to have been misinterpreted, participant allowed to continue with task as if the command was accepted properly).	
System	Would you like to do another transaction?		
User	No		
System	Thank you for calling, Goodbye		5:32

Unclassified

Participant 2 – Prototype C

Participant 2 (Prototype C)			
Speaking	Spoken	Comments	Time
Task 1	Task 1	Task 1	
System	<Intro>		3:40
System	Which Country?		
User	Germany		
System	We currently convert to German Marks at the rate of X German Marks per Aus \$, and from German Marks at the rate of X Aus \$s per German Mark.		
System	What amount would you like to convert?		
User	100		
System	100 German Marks converts to X Aus Dollars, and 100 Aus \$s converts to X German Marks.		
System	Would you like to do another transaction?		
User	Yes		5:20
Task 2	Task 2	Task 2	
System	Which Country?		5:21
User	Japan		
System	We currently convert to Japanese Yen at the rate of X Japanese Yen per Aus \$, and from Japanese Yen at the rate of X Aus \$s per Japanese Yen.		
System	What amount would you like to convert?		
User	10,000		
System	10,000 Japanese Yen converts to X Aus dollars, and 10,000 Aus \$ convert to X Japanese Yen		
System	Would you like to do another transaction?		
User	No		
System	Thank you for calling, Goodbye		6:51

Unclassified

Participant 3 – Prototype C

Participant 3 (Prototype C)			
Speaking	Spoken	Comments	Time
Task 1	Task 1	Task 1	
System	<Intro>		6:29
System	Which Country?		
User	Germany		
System	We currently convert to German Marks at the rate of X German Marks per Aus \$, and from German Marks at the rate of X Aus \$s per German Mark.		
System	What amount would you like to convert?		
User	100		
System	100 German Marks converts to X Aus Dollars, and 100 Aus \$s converts to X German Marks.		
System	Would you like to do another transaction?		
User	Yes		8:05
Task 2	Task 2	Task 2	
System	Which Country?		8:07
User	Japan		
System	We currently convert to Japanese Yen at the rate of X Japanese Yen per Aus \$, and from Japanese Yen at the rate of X Aus \$s per Japanese Yen.		
System	What amount would you like to convert?		
User	10,000		
System	10,000 Japanese Yen converts to X Aus dollars, and 10,000 Aus \$ convert to X Japanese Yen		
System	Would you like to do another transaction?		
User	No		
System	Thank you for calling, Goodbye		9:35

Unclassified

Participant 4 – Prototype C

Participant 4 (Prototype C)			
Speaking	Spoken	Comments	Time
Task 1	Task 1	Task 1	
System	<Intro>		3:14
System	Which Country?		
User	Germany		
System	We currently convert to German Marks at the rate of X German Marks per Aus \$, and from German Marks at the rate of X Aus \$s per German Mark.		
System	What amount would you like to convert?		
User	100..STS...100 after beep	<STS> Spoke before beep and then repeated 100 after hearing beep.	
System	For example, to convert 100 Aus \$, say 100 Aus \$s.		
User	100 Australian Dollars	May have taken the prompt as directions since the desired conversion amount matched and said "100 Australian \$s"	
System	100 Australian dollars converts to X German Marks.	<u>**System did not give both directions since he specified the currency as "Australian Dollars" so he noted the only conversion rate and amount given to him which was incorrect.</u>	
System	Would you like to do another transaction?		
User	Yes		4:54
Task 2	Task 2	Task 2	
System	Which Country?		4:57
User	Japan		
System	We currently convert to Japanese Yen at the rate of X Japanese Yen per Aus \$, and from Japanese Yen at the rate of X Aus \$s per Japanese Yen.		
System	What amount would you like to convert?		
User	10,000		
System	10,000 Japanese Yen converts to X Aus dollars, and 10,000 Aus \$ convert to X Japanese Yen		
System	Would you like to do another transaction?		
User	<No verbal response>	<Hangs up> because he is done with this systems tasks.	6:23

Unclassified

Participant 5 – Prototype C

Participant 5 (Prototype C)			
Speaking	Spoken	Comments	Time
Task 1	Task 1	Task 1	0:11
	Attempt 1	Attempt 1	
System	<Intro>		
System	Which Country?		
User	Germany		
System	We currently convert to German Marks at the rate of X German Marks per Aus \$, and from German Marks at the rate of X Aus \$s per German Mark.		
System	What amount would you like to convert?		
User	Well, I would like to have you repeat that rate please.	Natural language as input	
System	For example, to convert 100 AUS \$s, say 100 AUS \$s.		
User	<Talking to tester>	"I want it to repeat, how do I get it to repeat? It went on and on and on. I cant keep up with that."	
System	Sorry for the confusion, please call back later and try again, good-bye.		1:40
	Attempt 2	Attempt 2	
System	<Intro>		2:49
System	Which Country?		3:10
User	Germany		
System	We currently convert to German Marks at the rate of X German Marks per Aus \$, and from German Marks at the rate of X Aus \$s per German Mark.		
System	What amount would you like to convert?		
User	I have a hundred German Marks, how many dollars will I get?	Natural language as input	
System	One Hundred-Nine Thousand One Hundred German Marks converts to X AUS \$s		
System	100 German Marks converts to X Aus Dollars, and 100 Aus \$s converts to X German Marks.		
System	Would you like to do another transaction?		
User	I'de like you to repeat that, how many dollars will I get?	Natural language as input	
System	Please say either yes or no		
System	Sorry for the confusion, please call back later and try again, good-bye.	<Participant laughs> .. Asks, "am I stupid" User is instructed to use commands that are brief.	4:40
	Attempt 3	Attempt 3	
System	<Intro>		:00
System	Which Country?		
User	Germany		
System	We currently convert to German Marks at the rate of X German Marks per Aus \$, and from German Marks at the rate of X Aus \$s per German Mark.		
System	What amount would you like to convert?		
User	One hundred dollars... excuse me one hundred German Marks		
System	For example, to convert 100 AUS \$s, say 100 AUS \$s.		
User	One hundred German Marks.		
System	One hundred German Marks converts to X AUS \$s		
System	Would you like to do another transaction?		
User	Yes		1:42

Task 2		Task 2	
Attempt 1		Attempt 1	
System	Which Country?		1:44
User	Japan	<STS> Resulted in the system misinterpreting the input!	
System	We currently convert to Finnish Markas at the rate of X Finnish Markas per Aus \$, and from Finnish Markas at the rate of X Aus \$s per Finnish Markas.		
System	What amount would you like to convert?		
User	Repeat ...Japan...Yen	User confused as to what to do now that the currency conversion rate is for a country other than specified by the user	
System	For example, to convert 100 AUS \$s, say 100 AUS \$s.		
User	I want to convert 10,000 Japanese ...	<User cut off by system>	
System	Sorry for the confusion, please call back later and try again, good-bye.	<user asks, "why did it pick up Finnish, I didn't even use the word Finnish? Am I worse than most people..I feel like there is a lack of communication here."> (Later reports getting frustrated...even slightly angry).	2:54
Attempt 2		Attempt 2	
System	<Intro>		3:26
System	Which country?		
User	Japan		
System	We currently convert to Japanese Yen at a rate of X Japanese Yen per AUS \$ and from Japanese Yen at a rate of X AUS \$s per Japanese Yen		
System	What amount would you like to convert?		
User	10,000 Yen...how many dollars..	<Cut off by system>	
System	30,010 Japanese Yen converts to X AUS \$s and 30,010 AUS \$s converts to X Japanese Yen		
System	Would you like to do another transaction?		
User	NO!	<User is visibly upset>	
System	Thank you for calling Good bye	(Tester explains to the user that the system is not capable of extensive speech input and to be as brief as possible with the commands... and he is NOT stupid.) <i>Discontinued testing this system due to time constraints and user frustration level. 5 attempts for 2 scenarios. User no longer sees the humor in the reprints. Concerned he may end testing.</i>	5:22

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Participant 6 – Prototype C

Participant 6 (Prototype C)			
Speaking	Spoken	Comments	Time
Task 1	Task 1	Task 1	:10
System	<Intro>		
System	Which Country?		
User	Germany		
System	We currently convert to German Marks at the rate of X German Marks per Aus \$, and from German Marks at the rate of X Aus \$s per German Mark.		
System	What amount would you like to convert?		
User	100 German Marks		
System	100 German Marks converts to X Aus Dollars, and 100 Aus \$s converts to X German Marks.		
System	Would you like to do another transaction?		
User	Yes		1:34
Task 2	Task 2	Task 2	
System	Which Country?		1:36
User	Japan		
System	We currently convert to Japanese Yen at the rate of X Japanese Yen per Aus \$, and from Japanese Yen at the rate of X Aus \$s per Japanese Yen.		
System	What amount would you like to convert?		
User	10,000 Yen	10,000 Yen interpreted as 10,010.	
System	10,010 Japanese Yen converts to X Aus dollars, and 10,010 Aus \$ convert to X Japanese Yen		
User	Start Over	User asks system to "start over" in the middle of the conversion rate statement.	
System	Would you like to do another transaction?		
User	Yes		3:04
System	Which Country?		
User	Japan	<STS>	
System	For example, to convert German currency, say Germany		
User	Japan		
System	We currently convert to Japanese Yen at the rate of X Japanese Yen per Aus \$, and from Japanese Yen at the rate of X Aus \$s per Japanese Yen.		
System	What amount would you like to convert?		
User	10,000 Yen		
System	10,010 Japanese Yen converts to X Aus dollars, and 10,010 Aus \$ convert to X Japanese Yen	10,000 Yen interpreted as 10,010.	
User	<User hangs up>	User does not think the system is understanding properly since it has interpreted "10,000 Yen" as "10,010" twice. Ceases to attempt to complete this task. Notes the conversion amount (143.37 Y/D) anyway which is close to the correct amount (143.23).	4:29

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Appendix E. First-Attempt Turn-Taking Errors

We derived the data in the following tables from the data given in Appendix C. For both Prototypes A and B, a participant needed to respond to at least four prompts to complete a task. For Prototype C, participants responded to at least three prompts. Across the three prototypes and two tasks per participant, then, there were at least 22 opportunities to commit a turn-taking error. If an error resulted in a reprompt, the number of opportunities for that participant increased accordingly. The following table shows the number of opportunities for turn-taking errors present for first attempts to complete the tasks in this experiment.

First-Attempt Turn-Taking Error Opportunities

Participant	A1	A2	B1	B2	C1	C2	Total
1	4	7	5	5	3	3	27
2	5	4	4	4	3	3	23
3	4	4	4	4	3	3	22
4	5	4	5	6	4	3	27
5	5	6	4	4	4	4	27
6	4	5	4	4	3	3	23
<i>Total</i>	27	30	26	27	20	19	149

The next table shows the number of turn-taking errors committed in first attempts to complete the tasks, with each prototype during each task, broken down by STS and SWTS.

First-Attempt Turn-Taking Errors Committed

Participant	A1		A2		B1		B2		C1		C2		Total		Total
	STS	SWTS	STS	SWTS	STS	SWTS	STS	SWTS	STS	SWTS	STS	SWTS	STS	SWTS	Both
1	0	0	0	2	1	0	1	1	0	0	0	0	2	3	5
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	1	0	0	0	1	0	1
5	0	0	2	0	0	0	0	0	0	0	1	0	3	0	3
6	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1
<i>Total</i>	0	0	2	2	1	0	1	1	1	0	1	1	6	4	10

Finally, here is the statistical analysis of these data, collapsed across prototypes and tasks (presented in the Results section of this report).

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Statistical Analysis of Turn-Taking Error Frequencies

Participant	%STS	%SWTS	%Both	#Both
1	7.4	11.1	18.5	5
2	0.0	0.0	0.0	0
3	0.0	0.0	0.0	0
4	3.7	0.0	3.7	1
5	11.1	0.0	11.1	3
6	0.0	4.3	4.3	1
<i>Mean</i>	3.7	2.6	6.3	
<i>Std Dev</i>	4.68	4.53	7.24	
<i>Count</i>	6	6	6	
<i>sem</i>	1.91	1.85	2.96	
<i>df</i>	5	5	5	
<i>crit-t</i>	2.015	2.015	2.015	
<i>90% CI delta</i>	3.9	3.7	6.0	
<i>Upper</i>	7.6	6.3	12.2	
<i>Mean</i>	3.7	2.6	6.3	
<i>Lower</i>	-0.2	-1.1	0.3	

Appendix F. Raw Data for MOS Analysis

Participant	System	Global	Listen	Comp	Artic	Pron	Rate	Pleasant	Average
1	TTS	3	5	5	4	5	5	2	4.1
2	TTS	4	5	5	4	5	5	3	4.4
3	TTS	2	4	5	3	3	5	3	3.6
4	TTS	1	3	3	3	1	4	1	2.3
5	TTS	2	4	4	3	3	5	2	3.3
6	TTS	4	5	5	4	5	4	4	4.4
7	TTS	3	4	4	4	4	5	2	3.7
8	TTS	5	5	5	5	5	5	4	4.9
9	TTS	3	4	4	3	3	4	3	3.4
10	TTS	3	4	4	4	3	5	3	3.7
11	TTS	4	5	5	4	4	5	3	4.3
12	TTS	3	5	5	5	5	5	3	4.4
13	TTS	4	5	5	5	5	4	4	4.6
14	TTS	4	5	5	4	5	5	4	4.6
15	TTS	2	4	5	3	5	5	2	3.7
16	Wave	3	3	4	3	3	4	4	3.4
17	Wave	5	5	5	5	5	5	4	4.9
18	Wave	4	5	5	4	5	5	4	4.6
19	Wave	5	4	4	5	5	5	4	4.6
20	Wave	5	5	5	5	5	3	5	4.7
21	Wave	5	5	5	5	5	4	5	4.9
Average	TTS	3.1	4.5	4.6	3.9	4.1	4.7	2.9	4.0
Average	Wave	4.5	4.5	4.7	4.5	4.7	4.3	4.3	4.5
<i>t-tests</i>	<i>t</i>	2.812	0.099	0.228	1.71	1.099	1.442	3.661	1.794
	<i>df</i>	19	19	19	19	19	19	19	19
	<i>p</i>	0.011	0.922	0.822	0.1	0.285	0.166	0.002	0.089

The MOS uses 5-point scales. For this analysis, a higher number indicates a better rating. The seven MOS items (from Salza, 1996) are:

1. *Global Impression*: Your answer must indicate how you rate the sound quality of the voice you have heard.

Excellent

Good

Fair

Poor

Bad

Unclassified

2. *Listening Effort:* Your answer must indicate the degree of effort you had to make to understand the message.

- No effort required
- Slight effort required
- Effort required
- Major effort required
- Message not understood with any feasible effort

3. *Comprehension Problems:* Your answer must indicate if you found single words hard to understand.

- None
- Few
- Some
- Many
- Every word

4. *Speech Sound Articulation:* Your answer must indicate if the speech sounds are clearly distinguishable.

- Yes, very clearly
- Yes, clearly enough
- Fairly clear
- No, not very clear
- No, not at all

5. *Pronunciation:* Your answer must indicate if you noticed any anomalies in the naturalness of sentence pronunciation.

- No
- Yes, but not annoying
- Yes, slightly annoying
- No, annoying
- Yes, very annoying

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6. *Speaking Rate*: Your answer must indicate if you found the speed of delivery of the message appropriate.

- Yes
- Yes, but slower than preferred
- Yes, but faster than preferred
- No, too slow
- No, too fast

7. *Voice Pleasantness*: Your answer must indicate if you found the voice you have heard pleasant.

- Very pleasant
- Pleasant
- Fair
- Unpleasant
- Very unpleasant