Effects of Related and Unrelated Questions on the Speechreading of Sentences

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Adults with acquired hearing loss commonly use speechreading to reduce their communicative disability, yet little is known of the effects of communicative context on speechreading. This study examined the extent to which speechreading of sentences is affected by prior linguistic context. Forty adult participants with acquired hearing losses observed 40 sentences, presented visually-only, under 4 conditions of prior linguistic context: (a) related context, (b) alerting context, (c) unrelated context, and (d) no context. In the first 3 conditions a context utterance was read aloud by the participant prior to receiving the stimulus sentence. In the last condition the stimulus sentence was viewed in the absence of context cues. No significant difference was found between the alerting context and no context scores, and results for these 2 conditions were combined to form a neutral context condition. Participants identified key words in sentences significantly better when provided with related context cues than with neutral context cues or with unrelated context cues. Those scoring poorly in the absence of context cues benefited more from related contexts. Participants' scores were significantly poorer under the unrelated context condition, regardless of performance in the neutral context. The results suggest that there are 2 separate effects of linguistic context on speechreading: (a) the benefit associated with related context, and (b) the decrement associated with unrelated context, in contrast with the neutral context condition. The research implications of the findings include the need to select control conditions appropriate to the linguistic nature of the task.

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INTRODUCTION

There has been a trend in recent years for aural rehabilitation programs to become conversationally oriented (Erber, 1996; Kaplan, Bally, & Garretson, 1985; Tye-Murray, 1994). While speechreading training plays a large part in rehabilitation programs for adults with acquired hearing loss (Abrahamson, 1995; Gagné, 1994), the training continues to rely on analytic and synthetic techniques (Jeffers & Barley, 1971) which may not reflect real-world audiovisual speech perception experiences (Erber, 1992; Schiavetti, Sitler, Metz, & Houde, 1984). With the emphasis on successful conversation management as a rehabilitation goal for adults who have acquired hearing losses, there is a need to investigate how speech perception is influenced by the daily context(s) in which it occurs (Erber, 1996; Erber & Lind, 1994).

While speechreading of nonsense syllables, words, and sentences presented in isolation from conversational context has been shown to improve as a result of clinical training procedures (Crawford, Dancer, & Pittenger, 1986; Danz & Binnie, 1983; Walden, Erdman, Montgomery, Schwartz, & Prosek, 1981; Walden, Prosek, Montgomery, Scherr, & Jones, 1977), it has not been evaluated whether this improvement in speechreading performance will generalize to daily communication (Lesner, Sandridge, & Kricos, 1987). The greater the gap between the clinical materials used in training and real life application of the trained procedures, the greater the reliance on individuals to generalize these skills to their daily activities. This may be overcome partially by the development of speechreading materials and tasks with more emphasis on interactive communication.

Speechreading performance has been shown to be influenced by a variety of everyday contextual cues including manual gestures (Berger & Popelka, 1971; Popelka & Berger, 1971), situation/environment (Garstecki, 1976; Garstecki & O'Neill, 1980), facial expressions (Dudich & Duff, 1977; Miller, 1977), and topic (Boothroyd, 1988; Smith & Kitchen, 1972). In each of these studies, provision of contextual information related to the stimulus utterance (i.e., that supported, confirmed, or extended) resulted in more accurate perception than when a stimulus was presented either in isolation from a context cue or following an unrelated context cue.

Similarly, improvement in accuracy of speechreading of sentences associated with the provision of prior conversation context has been demonstrated in both a narrative or *within turn* format (Gagné, Tugby, & Michaud, 1991) and in an interactional or *across-turn* format (Erber, 1992). In the Gagné et al. (1991) study, adults with hearing impairment observed a single videotaped talker present a two-sentence narrative sequence. In each trial, the stimulus sentence (presented visually only) immediately followed a context sentence, which was both spoken on the video and captioned to reduce ambiguity. In half the trials the context sentence was paired with its related stimulus sentence. In the other half of the trials each context sentence was randomly reassigned to a stimulus sentence such that the two utterances were judged by the researchers to be unrelated. The influence of prior related context was determined by comparing key-word identification scores under the related context condition with those under the unrelated context condition. Results indicated that, in a narrative format, identification of words in sentences was significantly better following the presentation of related sentence-length context cues than when following unrelated sentence contexts.

In the Erber (1992) study, adults with hearing impairment speechread videotaped sentences presented without sound, either in isolation or following sentence-length context cues. In this study the context cue was a predetermined *Why* question, which was judged to form a highly natural (i.e., occurring in daily conversation) question/answer pair with the stimulus sentence. Under the related context condition, the participant read aloud the context question from a card, prior to the videotaped presentation of the stimulus sentence. Under the no context condition, the stimulus sentence was presented in isolation. Results indicated that key-word speech perception scores were significantly better when sentences were preceded by a related context question, than when sentences were presented in isolation.

In summary, while both studies found the provision of related context cues resulted in significantly better speechreading scores, Gagné et al. (1991) measured the benefit associated with related context cues against an unrelated context condition, while Erber (1992) compared it with a no context condition. The question remains, in establishing the benefit associated with prior related context cues, whether these two control conditions exert similar influences on the ability to speechread stimulus sentences.

Two speechreading-in-context studies compared the benefit of a related context with both unrelated and no context conditions (Garstecki, 1976; Popelka & Berger, 1971). Both found significantly better speech reception under related context conditions, than under either the no context or unrelated context conditions. Garstecki (1976) investigated the influence of situational cues and found no significant difference between the no context and the unrelated context conditions. Popelka and Berger (1971), examining the influence of facial expressions on speechreading, found that sentences were identified better under a no context condition than in the presence of unrelated context. It remains to be established whether related and unrelated prior *linguistic* context cues differentially influence sentence-based speechreading by comparison with a no context condition.

Both psycholinguistic (Stanovich & West, 1981, 1983) and speechreading research (Lansing & Helgeson, 1995) have indicated that performance on word identification tasks is influenced by the presentation of context cues that are semantically related to the stimulus, relative to performance in the absence of context cues and following unrelated context cues. These studies have indicated that the inhibitory (or distracting) effects of unrelated context result in poorer performance in word identification than occurs following a no context condition. Jonides and Mack (1984) suggest that related and unrelated context cues influence word identification in two ways, based on: (a) the relationship between the content of the contextual cue and the stimulus, and (b) the capacity of the context cue to alert the participant to the upcoming stimulus. To clarify this relationship, Jonides and Mack proposed the inclusion of a fourth context condition to assess the *alerting* properties of the context cues in the absence of contextual information. An alerting context would have a linguistic structure similar to the related and unrelated contexts, but without semantic content. The question arises whether the alerting properties of such a context would yield better speech perception results than a no context condition. Therefore the aims of the study are to: (a) reassess the benefit associated with related context cues by contrast with unrelated context cues, (b) compare the effects of an alerting context and a no context condition, and (c) assess the effects of the context laden (related and unrelated) conditions with the two context neutral (alerting and no) conditions.

People with hearing loss differ in their ability to speechread sentences in isolation. Lyxell and Rönnberg (1987a, 1987b) found poorer speechreaders, when presented with context cues, improve more than better speechreaders. Stanovich and West (1983) found poorer readers to be more susceptible to both related and unrelated prior context cues in written sentence perception tasks. Lansing and Helgeson (1995) found little variability in context effects on single word speechreading by participants with normal hearing levels. Consistent evidence is not yet available about whether people with hearing loss are equally influenced by context cues in sentence perception. The presence or absence of these effects in the speechreading of adults with acquired hearing losses is important for planning rehabilitation programs so that individuals who benefit from such cues may be identified for training regimens specific to their needs and abilities.

In summary, five experimental questions were framed to investigate the relationship between speechreading performance under related, alerting, no context, and unrelated context cues. The following questions were considered: Does a related context enhance speechreading performance in comparison with an unrelated context? Does an alerting context affect speechreading differently from a no context condition? Does related context enhance speechreading performance differently from the neutral context conditions? Does unrelated context result in a decrement in speechreading performance in comparison with the neutral context conditions? Are all participants equally influenced by prior related and unrelated linguistic context?

METHOD

The design of this project, in part, follows that used by Erber (1992) with 40 sentence pairs, each composed of an initiating question (to be read aloud by the participant), and a stimulus sentence (to be presented visually-only by a videotaped talker). Each participant received the same 40 stimulus items in the same order but under a semi-randomized allocation of four experimental conditions. Each condition was based on the relationship between the initiating question and the stimulus sentence that followed (i.e., 10 stimuli under each of the related, unrelated, alerting, and no context conditions). The materials, participants, and experimental procedures are detailed in the following sections.

1) Materials

An initial corpus of 200 question/answer sentence pairs was constructed. Each pair consisted of a *Why* question initiator (e.g., "Why do you travel by taxi so often?") followed by a stimulus sentence (e.g., "I don't have my driver's license."). All initiator and stimulus sentences were between 5 and 10 words (between 6 and 13 syllables) in length.

A paper-and-pencil rating task was used to assess the *naturalness* of each of the 200 stimulus sentences and to assess the *cohesion* of each of the 200 sentence pairs. Twenty native Australian English speakers, who ranged in age from 22 to 70 years (mean age = 40.2 years, *SD* = 15.2 years), participated as raters. The highest educational levels of the raters varied: 4 had graduated high school; 16 had completed or were attending university. They reported normal hearing and satisfactory vision for reading (corrected or uncorrected). They were randomly assigned to either the naturalness rating task or to the cohesion rating task. The participants rated each sentence pair, presented in written format, on a 7-point scale from *low* to *high.* Participants in this task were requested to rate each of the 200 response sentences (i.e., the second sentence of the question/answer pair) for naturalness, which was defined as the everyday-ness of the sentence (Brown & Yule, 1983; Erber, 1992; Levinson, 1983). Similarly, the participants in the second group were asked to rate the 200 sentence pairs for cohesion, which was defined as the degree to which the second sentence of a pair was indicated or implied by the first (Halliday & Hasan, 1976). The naturalness and cohesion ratings were used to select 48 stimulus sentences which were randomized and videorecorded. Of the original 200 sentence pairs the final group of 48 pairs were those with highest ratings in both cohesion and naturalness. Of the 48 sentence pairs, the first 8 sentences were used as practice items (and were therefore not scored), and the remaining 40 sentences were used as test items (see Appendix).

To select the important *(key)* words for scoring purposes, the 40 test sentences were presented in written form to five staff members. These persons who were experienced with clinical/research aspects of speechreading were asked to identify five key words in each stimulus sentence. Of the 200 key words (i.e., 5 words × 40 sentences), agreement occurred across the five judges for 180 words. The researcher chose the remaining 20 key words.

In order to select a talker for the videorecording whose speech was representative, 10 native Australian English females were videotaped, each reading a brief passage and 10 of the 48 sentence stimuli. They were instructed to speak naturally, slightly slower than usual, without exaggerating. The head and shoulders of each talker were videotaped against a plain black background, using lighting from a single source facing the talker from behind the camera to minimize shadows. To minimize the likelihood of selecting a talker who had idiosyncratic speech patterns, two groups of three experienced Speech Pathologists rated the 10 talkers for clarity of speech by judging the *symmetry* and *excursion* of their speech movements. The participants were asked to rate the symmetry and excursion of each talker's speech on 7-point scales from *Low* to *High* for each descriptor. The raters watched each talker without sound, rating visible articulation only. For the purposes of this exercise, Symmetry was defined as movement of the articulators about both the horizontal axis (the corners of the talker's mouth) and the vertical axis (an imaginary vertical line drawn through the center of the top lip at rest). Excursion was defined as the amount of horizontal and vertical mouth opening. Maximum symmetry in combination with moderate excursion (i.e., avoiding *overarticulation*) were considered desirable for clear speechreadability.

The six raters scored each variable on a 7-point scale, so the maximum possible score was 42 and the minimum score was 6. Symmetry scores ranged from 22 to 34, with a median score of 30. Scores for excursion ranged from 14 to 27 with a median of 24. Three talkers rated highly on symmetry, scoring 33 or 34. One of them, J.K., who scored closest to the median score in excursion was then selected to be videorecorded reading the stimulus sentences. J.K. (30 years) was selected to read the stimulus sentences. A professional quality camera, video recorder, and editing suite were used to produce the final color videotape, a head-and-shoulders view of the talker.

2) Participants

Participants for the study were 40 adult volunteers (14 males and 26 females) with bilateral hearing impairment. Participants' ages ranged from 25 to 76 years with a mean of 53.6 years (*SD* = 13.7 years) and were second generation Australian English speakers. Four-frequency, better-ear pure-tone averages (0.5, 1, 2, and 4 kHz) ranged from 16 to 120 dB HL (American National Standards Institute [ANSI], 1969) with a mean of 54.2 dB HL (*SD* = 29.3 dB HL). No limitations were placed on the degree of hearing loss of the participants in this study, other than they have thresholds poorer than 25 dB HL at two frequencies in the better ear (refer Table 1).

Participants who used hearing prostheses wore them during the experiment for ease of communication with the experimenter. Participants reported no history of neurological impairment and had not previously received training in speechreading. All participants had corrected or uncorrected vision of at least 6/12 (20/40) on a Snellen chart. Eighteen participants wore corrective lenses while 22 participants did not. These were worn during the experiment if required.

3) Experimental Procedures

Each participant was tested individually and was required to speechread 40 stimulus sentences, presented visually-only on a television monitor. Each participant sat in a dimly lit 2 m by 3 m room, 1.5 m from a 48 cm color video monitor (Sony KX-20PS1) operated from a stereo video recorder (Panasonic NV-HD100). A life size image of the talker's head and shoulders appeared on the screen of the video monitor.

Speechreading performance was measured under four experimental conditions, defined by the relationship between an initiating question read aloud by the participant and the stimulus sentence that followed on the video monitor. The 40 stimulus sentences were presented in the same order, but the four context conditions were semi-randomized across trials. Each participant saw a unique sampling of context/stimulus pairings. That is, each context condition occurred in every set of four trials. The ordering of the four conditions within each set of four trials was randomized with the provisos that: (a) no context condition occurred twice in a row, and (b) each stimulus sentence was preceded by each context type an equal number of times (i.e., 10). Further details of the allocation of the context sentences and analysis of the effects of context types on speechreading of each stimulus sentence are described elsewhere (Lind, 1996).

Overall, each person received 10 stimulus sentences under each condition. During a related context condition, the participant received a card with the related *Why* question printed on it. During an unrelated context condition, the participant also received a card containing a *Why* question, which was not related to the stimulus sentence that followed. During an alerting context condition, the participant received a card that read "What's been happening?," a question considered to have no semantic content. Finally, during a no context condition, the participant received a blank card and speechread the stimulus sentence in isolation.

In order to present the context/stimulus pairings within a standardized time interval, equipment was designed to control the interstimulus interval (i.e., the time between the end of the participant reading aloud the context utterance and the onset of the videotaped stimulus sentence). Typical conversation turn-taking includes a very narrow range of between-talker pause times (Jaffe & Feldstein, 1970). Yet the timing of turn sequences has been largely ignored in speechreading studies of sentence perception (although see Erber, 1992). A variable or uncontrolled interstimulus interval in sentence-in-context speechreading studies may result in memory (Rönnberg, Ohngren, & Nilsson, 1982, 1983) and/or pragmatic (Levinson, 1983; Nofsinger, 1991) effects.

As the participant read the context sentence aloud from each card, the researcher operated specially constructed delay timer equipment. This voice-activated apparatus controlled the interval between the offset of the initiating sen-

Table 1

Participant Characteristics and Speechreading Scores (Maximum Scores)

Participant initials	Gender	Age[a]	4 Frequency BEPTA[b]	Unrelated[c]	Alerting[c]	No[c]	Related[c]
P.T.	M	56	56	3	2	6	14
G.G.	M	50	111	24	28	29	45
A.T.	F	39	61	26	32	27	42
E.K.	F	50	20	10	5	11	26
T.R.	M	73	76	12	11	7	27
L.W.	F	43	56	8	17	·17	35
G.C.	M	76	96	3	3	10	26
L.J.	F	49	56	18	16	18	24
K.P.	M	66	21	4	12	9	21
J.A.	F	39	18	6	5	4	30
I.H.	F	65	110	20	25	21	27
L.G.	F	63	120	18	15	13	40
R.D.	F	38	54	3	5	4	27
J.R.	M	64	30	1	3	0	10
C.M.	M	48	70	36	35	36	42
G.S.	M	49	44	8	20	14	30
K.B.	M	53	119	22	20	27	38
H.M.	F	75	35	5	13	13	26
L.G.	M	73	101	0	7	4	19
D.G.	F	64	34	8	16	8	22
G.L.	F	51	31	5	7	17	31
J.S.	F	39	80	29	33	38	40

Continued on next page

Table 1 *Continued from previous page*

Participant initials	Gender	Age[a]	4 Frequency BEPTA[b]	Unrelated[c]	Alerting[c]	No[c]	Related[c]
R.R.	F	64	36	2	0	4	8
R.Q.	M	24	21	12	10	3	30
V.W.	F	76	35	3	13	3	20
E.L.	F	73	49	0	8	1	33
N.W.	F	49	41	4	17	15	32
J.G.	F	53	16	6	15	12	28
J.I.	F	30	60	16	27	20	37
C.M.	F	56	32	6	9	12	26
A.H.	F	63	18	7	15	13	27
G.L.	M	59	39	15	29	22	39
D.J.	F	41	71	30	29	27	40
J.S.	F	69	86	11	12	4	32
N.A.	M	37	54	20	36	38	39
M.S.	F	65	41	5	5	4	11
M.E.	F	37	44	25	34	40	45
R.T.	M	60	50	4	8	12	17
J.S.	F	43	41	1	13	7	21
S.T.	F	25	36	24	22	25	36
M		53.6	59.2	11.25	15.73	14.95	29.08

Note. M = Male, F = Female.
[a]Age rounded to nearest year. [b]4 Frequency BEPTA = four frequency (0.5, 1, 2, and 4 kHz) better ear pure tone average in dB HL (ANSI, 1969). [c]Unrelated, Alerting, No, and Related refer to the four original prior context conditions (maximum score = 50). Scores on the Alerting and the No context trials were combined into the Neutral context, and the four original conditions were combined into the Total speechreading score (maximum score = 200).

tence (read aloud by the participant) and the onset of the videorecorded stimulus sentence. The pause time was set at 1 s (Jaffe & Feldstein, 1970). A brief tone recorded on one audio track signaled the timing equipment to pause the video tape just before the first discernible speech movement made by the talker on the video. When the apparatus detected the offset of the participant's spoken question, the video recorder was automatically released from pause mode. After reading the context sentence aloud, the participant looked up at the video monitor and the stimulus sentence appeared (without sound). In the no context condition, where the card presented to the participant was blank, the participant was instructed to look up at the video monitor. The researcher manually activated the video player via the remote control approximately 1 s after the participant looked up. After viewing the stimulus sentence, regardless of condition, the participant repeated as much of it as possible, and the researcher transcribed the participant's spoken response. To check the reliability of the researcher's scoring, a sample of the participants' test sessions was audiotaped and scored independently by another researcher. Agreement between the two sets of scores was above 98%.

Speechreading performance was measured by the number of key words correctly identified in each sentence. Contractions and expansions (e.g., *can't* for *cannot* and vice versa) were scored as correct. Words identified with incorrect tense or number marker morphemes (e.g., *shoe* for *shoes* or *have* for *had*) also were scored as correct. Plurals that changed form (e.g., *people* for *person* or *child* for *children*) were marked as incorrect, as were verbs without negative markers (e.g., *have* for *haven't*). A speechreading score for each context condition was derived for each participant from the 10 sentences presented under that condition (10 sentences × 5 key words = 50 maximum score).

RESULTS

The 40 participants each speechread 10 sentences under each of the four context conditions. Statistical analysis was performed using the StatView SE + Graphics (1989) software program. Speechreading scores for each participant under each condition are presented in Table 1. The mean speechreading scores for the 40 participants under the four context conditions were: (a) 29.08 under the related context condition (range: 8 to 45, $SD = 9.63$), (b) 15.73 under the alerting context condition (range: 0 to 36, $SD = 10.32$), (c) 14.95 under the no context condition (range: 0 to 40, $SD = 11.05$), and (d) 11.25 under the unrelated context condition (range: 0 to 36, $SD = 9.40$).

Planned comparisons, based on the first four experimental research questions, examined differences among four specific pairs of treatment means. Because the number of the paired comparisons exceeded the principle of orthogonality (Cohen, 1988; Keppel, 1973), the desired α level was divided by the number of comparisons to achieve a modified criterion at $\alpha = .05/4 = .013$ (rounded to .01) (Harris, 1975).

Question 1: The first comparison addressed whether the related context enhances speechreading performance by comparison with the unrelated context. Results indicated significantly higher speechreading scores under the related context condition in comparison with the unrelated context condition, $F(1, 39) = 274.79$, $p = .0001$.

Question 2: The second planned comparison addressed whether an alerting context affected speechreading differently from a no context condition. No significant difference was found between speechreading scores under the alerting context condition and the no context condition, $F(1, 39) = 0.98$, $p = .33$. These two conditions were thus collapsed into one condition, and the results were averaged. Scores on this combined condition ranged from 1.5 to 37.0, with a mean of 15.34 ($SD = 10.39$). These scores are referred to as the *neutral* context condition for the following analyses.

Question 3: The third planned comparison addressed whether the related context enhanced speechreading performance differently from the neutral context condition. Results indicated that key word identification under the related context condition was significantly better than under the neutral context condition, $F(1, 39) = 183.20$, $p = .0001$.

Question 4: The fourth experimental question addressed whether the unrelated context resulted in a decrement in speechreading performance when compared with the neutral context condition. Analysis indicated that key word identification under the neutral context condition was significantly better than under the unrelated context condition, $F(1, 39) = 24.26$, $p = .0001$.

In summary, the speechreaders derived significant benefit from sentences presented following the related context, in comparison with those following the unrelated context cues. They derived no more benefit from sentences presented following an alerting question than from sentences presented in isolation (i.e., without context). The results from the alerting context and no context conditions, therefore, were collapsed into a neutral context condition. Speechreaders received significant benefit from prior related linguistic context but significant decrement from prior unrelated linguistic context when performance was compared with the neutral context condition.

Question 5: The fifth experimental question, whether all participants were equally influenced by prior related and unrelated linguistic context, was addressed in two ways. First, the relationship between degree of hearing loss and speechreading scores was investigated. Pearson's Product Moment correlations were calculated for the relation between the better ear pure-tone average and six speechreading scores (i.e., the four original context conditions, the neutral context condition, and the total speechreading score). Again, as the number of correlations exceeded the principle of orthogonality (Cohen, 1988; Keppel, 1973), a modified criterion at $\alpha = .05/6 = .008$ (rounded to .01) was used (Harris, 1975). As shown in Table 2, the results showed a significant correlation only in the re-

Table 2
Pearson's Correlations of Hearing Loss and Speechreading Scores

Speechreading condition	Pearson's r value
Related context	.35
Alerting context	.29
No context	.30
Neutral context	.30
Unrelated context	.42*
Total speechreading score	.36

Note. Hearing loss measured by better ear four frequency (0.5, 1, 2, and 4 kHz) pure tone average (re: ANSI, 1969).
*p < .01

lationship of hearing loss and the unrelated context condition scores, $r(39) = .43$, $p < .01$, but it was of only a moderate degree.

The second way Question 5 was addressed was to divide participants into post hoc *Better* and *Poorer* groups based on visual analysis of the neutral context speechreading data (see Figure 1). Group results for the *Better* ($n = 12$, scores 28 to 37) and the *Poorer* ($n = 28$, scores 0 to 17) groups for the three context conditions (i.e., related, neutral, and unrelated) are presented in Figure 2. Two planned comparisons between the two groups were conducted based on difference scores: (a) between the related and neutral contexts, and (b) between the neutral and the unrelated contexts. Single factor ANOVA results showed that the *Poorer* group benefited more from the presentation of related context than did the *Better* group, $F(1, 38) = 6.65$, $p = .01$. A single factor ANOVA indicated that there was no significant difference between the two groups in the decrement in performance under the unrelated context condition, $F(1, 38) = 2.58$, $p = .12$.

To further investigate the benefit associated with the presentation of related context over neutral context for individual participants, a measure of relative improvement may be calculated from the logarithm of the ratio of the scores obtained with related context and those obtained with the neutral context (Levitt, Waltzman, Shapiro, & Cohen, 1986). In order for a difference score between two conditions to reach significance, the ratio of the two values should be greater than 1.96 × the average standard deviation of the logarithm of the ratio of the two conditions. For the related and neutral contexts, this value was .23, and the critical difference ratio (assuming $\alpha = .05$, two-tailed test) to achieve significance is the antilog of $1.96 \times .23/40 = 1.18$. All but three of the 40 participants (all from the *Better* group) achieved significantly greater scores with related context than with neutral context. Applying the same method to the scores obtained under neutral and unrelated context conditions, the critical difference ratio, with the same assumptions, is the antilog of $1.96 \times .30/40 = 1.24$. Using this criterion, 24 of the 40 participants (41.7% of the *Better* group and 67.9% of the *Poorer* group)

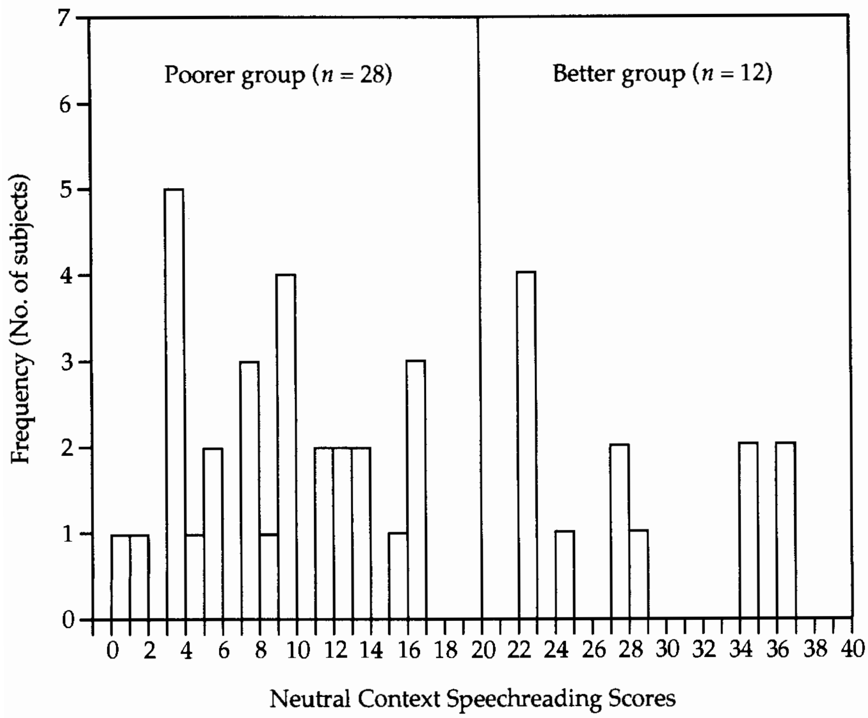

Figure 1. Frequency distribution of neutral context speechreading scores ($N = 40$). Scores were divided into *Better* and *Poorer* groups.

achieved scores under the neutral context condition that were significantly greater than under the unrelated context condition. None of the difference scores of the participants who performed better on the unrelated context condition than on the neutral context condition reached significance.

In summary, these results indicate low correlations between the various speechreading scores and participants' better ear hearing levels, with only the unrelated context speechreading correlation reaching significance. Further, while the majority of participants benefited from related context, overall those in the *Poorer* group gained more benefit than did those in the *Better* group. Although more than half of the participants were adversely influenced by the unrelated context, no significant difference between groups occurred in this effect.

Stimulus sentence visibility was considered to be an important variable in speechreadability, so visibility ratings were calculated for each of the 40 stimulus sentences using two methods. The first used the four phoneme visibility indices described by Ickes (1980). Under each weighting system, every phoneme in the sentence is given a visibility rating of 0.25, 0.5, 0.75, or 1.00, with higher ratings indicating higher visibility. The total visibility value for the sentence was divided

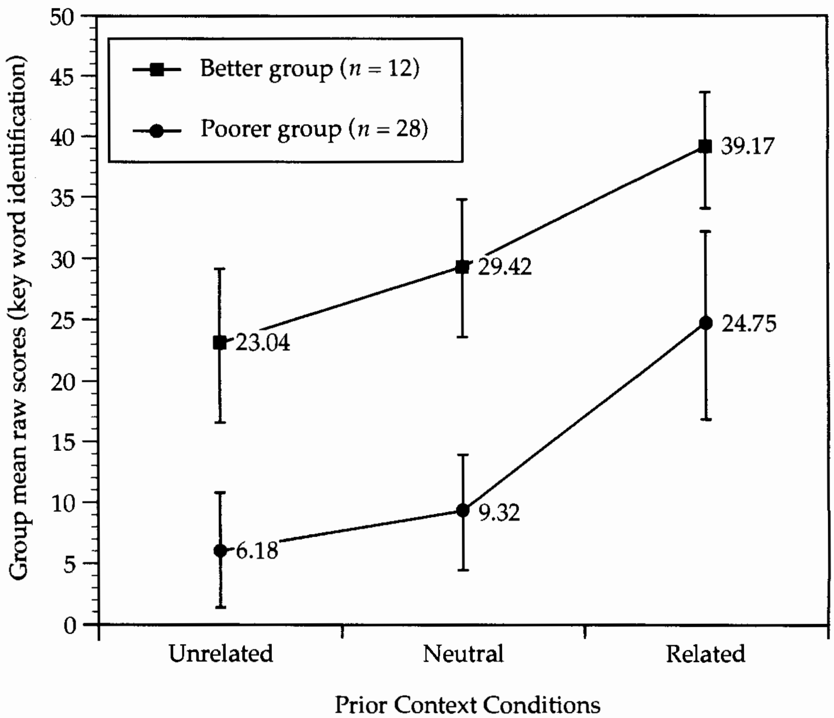

Figure 2. Mean speechreading scores for the *Better* and the *Poorer* groups under the three prior context conditions (maximum score: 10 sentences × 5 key words = 50). Error bars represent standard deviations.

by the number of phonemes in that sentence. The second method calculated the ratio of consonants to vowels for each stimulus sentence (Clouser, 1976). The five visibility values for each stimulus sentence were used for comparison with speechreading scores.

The effects of segmental visibility on speechreadability were investigated as the 40 stimulus sentences were not controlled a priori for phoneme visibility. Table 3 summarizes the results of the Pearson's Product Moment correlations of the five visibility ratings for the stimulus sentences with speechreading scores under the related, neutral, and unrelated context conditions, again using a modified $\alpha = .01$. Only the correlation between consonant/vowel ratio and scores under the neutral context condition reached significance, $r(38) = .43$, $p < .01$.

DISCUSSION

The purpose of this study was to determine whether prior linguistic context cues differentially affect the speechreading of sentences by adults who have ac-

Table 3
Pearson's Correlations of Phoneme Visibility Ratings and Speechreading Scores Under the Related, Neutral, and Unrelated Context Conditions

Phoneme visibility weighting systems	Related context *r*	Neutral context *r*	Unrelated context *r*
American Hearing Society[a]	.23	.24	.20
O'Neill[a]	.24	.31	.20
Woodward & Lowell[a]	-.13	.14	-.03
Berger[a]	.18	.17	.21
Consonant/vowel ratio	.43*	.10	.16

[a]Names identified by Ickes (1980) for the four phoneme visibility weighting systems.
*p < .01

quired hearing loss. Forty participants each read 40 sentences, 10 under each of four different conditions. Conditions were defined by the type of prior contextual information the participant received. The results indicate that participants in this study speechread stimulus sentences most accurately when preceded by a related context, less accurately when preceded by no contextual information, and even less accurately when preceded by an unrelated context. These findings together with the Erber (1992) and the Gagné et al. (1991) studies clarify the influence of prior context on sentence-based speechreading performance. Erber (1992) found participants speechread sentences more accurately when preceded by a related context cue than when they speechread sentences in isolation. The current study not only confirmed these results, but also included two separate context-free conditions, namely the no context and the alerting context conditions, designed only to differ in their ability to alert the individual to the upcoming stimulus. No difference was found in speechreading scores between the no context and the alerting context conditions. Contrary to Jonides and Mack's (1984) argument for the inclusion of an alerting context condition, it may be suggested that the alerting properties associated with the alerting condition used in this study did not influence participants' performance.

Gagné et al. (1991) found speechreading performance to be superior when sentences were preceded by a related context than by an unrelated context. The results of the present study showed: (a) a difference between the related context speechreading scores and both the neutral context and the unrelated context, and (b) a difference in performance between the neutral context and the unrelated context conditions. That is, the comparison between a related context and an unrelated context condition may be divided into: (a) the benefit of related context relative to the neutral context condition and (b) the decrement associated with unrelated context relative to neutral context.

To evaluate the influence of hearing levels on speech perception performance, speechreading scores under the four original conditions, the neutral condition, and the total score were compared with better ear hearing thresholds. Only the correlation between hearing level and speechreading scores preceded by unrelated context reached significance, such that the greater the hearing loss the better the speechreading performance. This relationship, although of only a moderate degree, may indicate that, in the face of incongruous information, adults with greater hearing loss more successfully use the sensory-perceptual information within the stimulus and rely less on the immediate linguistic context preceding it. This finding confirms previous research (Pelson & Prather, 1974) on the effects of hearing loss on speechreading performance.

To further investigate whether the context cues influenced speechreaders equally, participants were split into two groups based on their sentence-in-isolation speechreading abilities (i.e., by scores in the neutral context condition). While most participants showed improved speechreading scores with related context, the *Poorer* group benefited significantly more than did the *Better* group. Lyxell and Rönnberg (1987a) also found that less skilled speechreaders showed greater improvement in sentence perception when related context cues were provided. In the present study, a majority of participants performed more poorly on the unrelated context than on the neutral context, but no significant difference in the influence of the unrelated context was noted between the two groups. In contrast, Stanovich and West (1981) found that poorer participants were more influenced by both related and unrelated contexts in a written sentence perception task. The results of the present study indicate that while poorer speechreaders seem to benefit from the addition of context cues, both groups of speechreaders are influenced by misleading context cues. There is a continuing need to investigate speechreading of sentences in context across a wider range of stimulus and context conditions and in relation to individuals' underlying sensory and linguistic skills.

The findings in this study represent an initial examination of the perception of items in stimulus sentences given various prior contextual cues. Other sources of participant variability in performance include: (a) the realism of the task, (b) the linguistic predictability and phoneme visibility of the stimulus materials, and (c) the temporal patterns of the utterance sequences. First, the experimental design required individuals to take a role in the task and to accept that the context established by the trial exists for the purpose of the trial. Some participants reported this to be an easy task, while others felt it was unnatural. Erber (1992) suggests that certain participants, who do not improve in their speechreading performance when related context is offered, may not have taken the role of conversation partner within the context of the specific trial or across all trials. The ability of an individual to assume such roles in the clinic may constitute an important aspect of the success of "conversation-based" intervention (Erber, 1996).

Comparison of speechreading scores under each of the various prior linguistic context conditions has indicated the benefit associated with related context cues. A more complete evaluation of the relative strength of the context effects in speechreading would involve the assessment of the ability of the language cues in the context utterance to direct the individual to the key words in the stimulus utterance. Participants' ability to guess the stimulus sentence from the prior context cue alone would allow the predictability of the context sentence/stimulus sentence pair to be evaluated. This would provide a measure of the cohesion within each sentence pair without the benefit of the visual presentation of the stimulus utterance. Key word scoring may then be modified to take into account those words which could be predicted from the context alone.

A comparison of sentence visibility (Clouser, 1976; Ickes, 1980) and speechreading performance under the various context conditions revealed only a small significant relationship between the consonant-vowel ratio and speechreading scores under the neutral context condition. The premise underlying visibility ratings is that the visibility of a unit of speech is inherent in the sentence itself and is relatively constant across talkers. It has been demonstrated that talker clarity varies (Demorest & Bernstein, 1992; Kricos & Lesner, 1982; Lesner & Kricos, 1981), and thus individual variations in visible speech characteristics may have influenced performance. Although selected for the task based on broad measures of her clarity of speech, no account was taken of the talker's segmental speech visibility as she read the stimulus sentences.

The development of conversational-analytic rehabilitation programs, in which spoken language materials are embedded in everyday conversational context(s), may increase the everyday reality of speechreading materials. In such programs, assessment and intervention protocols would distinguish speech perception abilities following related contexts (representing "reasonable" consecutive across-turn utterances) from context-neutral prior utterances (providing no topic or content cues) and unrelated sentence contexts (providing incongruous sequences). This study, alongside Erber (1992) and Gagné et al. (1991), suggests that speechreading performance varies across these context conditions, but not all adults who have acquired hearing loss are equally or similarly influenced by them.

CONCLUSIONS

This study has demonstrated that contextual information presented prior to the perception of a target sentence can influence the accuracy with which that sentence is identified, but not all individuals are equally influenced by contextual cues. To increase the naturalness of the tasks by which we assess and train speechreading skills, further research is required into the everyday linguistic and extralinguistic factors that can influence speech reception. While the incorporation of these contextual cues into research and therapeutic paradigms may enhance the realism of the tasks, questions remain about the nature of these contextual relationships, their generalizability across a wider sample of language tokens, and the efficacy of their use in intervention.

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REFERENCES

Abrahamson, J. (1995). Effective and relevant programming. In P.B. Kricos & S.A. Lesner (Eds.), *Hearing care for the older adult* (pp. 75-112). Boston: Butterworth-Heinemann.

American National Standards Institute. (1969). *Specifications for audiometers* (ANSI S3.6-1969). New York: Author.

Berger, K.W., & Popelka, G.R. (1971). Extra-facial gestures in relation to speechreading. *Journal of Communication Disorders, 3,* 302-308.

Boothroyd, A. (1988). Linguistic factors in speechreading. *Volta Review, 90*(5), 77-87.

Brown, G., & Yule, G. (1983). *Discourse analysis.* Cambridge, England: Cambridge University Press.

Clouser, R.A. (1976). The effect of vowel consonant ratio and sentence length on lipreading ability. *American Annals of the Deaf, 121,* 513-518.

Cohen, J. (1988). *Statistical power analysis for the behavioural sciences.* Hillsdale, NJ: Erlbaum.

Crawford, J., Dancer, J., & Pittenger, J. (1986). Initial performance level on a speechreading task as related to subsequent improvement after shortterm training. *Volta Review, 88,* 101-105.

Danz, A.D., & Binnie, C.A. (1983). Quantification of the effects of training the auditory-visual reception of connected speech. *Ear and Hearing, 4,* 146-151.

Demorest, M.E., & Bernstein, L.E. (1992). Sources of variability in speechreading sentences: A generalizability analysis. *Journal of Speech and Hearing Research, 35,* 876-891.

Dudich, M.A., & Duff, M.A. (1977). The effect of appropriate facial expressions on speechreading ability. In K.W. Berger (Ed.), *Research studies in speechreading* (pp. 8-13). Kent, OH: Herald Publishing House.

Erber, N.P. (1992). Effects of a question-answer format on visual perception of sentences. *Journal of the Academy of Rehabilitative Audiology, 25,* 113-122.

Erber, N.P. (1996). *Communication therapy for adults with sensory loss* (2nd ed.). Melbourne, Australia: Clavis.

Erber, N.P., & Lind, C. (1994). Communication therapy: Theory and practice. In J.-P. Gagné & N. Tye-Murray (Eds.), *Research in audiological rehabilitation: Current trends and future directions* [Monograph]. *Journal of the Academy of Rehabilitative Audiology, 27,* 267-287.

Gagné, J.-P. (1994). Visual and audiovisual speech perception training: Basic and applied research needs. In J.-P. Gagné & N. Tye-Murray (Eds.), *Research in audiological rehabilitation: Current trends and future directions* [Monograph]. *Journal of the Academy of Rehabilitative Audiology, 27,* 133-159.

Gagné, J.-P., Tugby, K.G., & Michaud, J. (1991). Development of a Speechreading Test on the Utilization of Contextual Cues (STUCC): Preliminary findings with normal-hearing subjects. *Journal of the Academy of Rehabilitative Audiology, 24,* 157-170.

Garstecki, D.C. (1976). Situational cues in visual speech perception. *Journal of the American Audiological Society, 2,* 99-106.

Garstecki, D.C., & O'Neill, J.J. (1980). Situational cue and strategy influence on speechreading. *Scandinavian Audiology, 9,* 147-151.

Halliday, M.A.K., & Hasan, R. (1976). *Cohesion in English.* London: Longman.

Harris, R.J. (1975). *A primer of multivariate statistics.* New York: Academic Press.

Ickes, W.K. (1980). Viseme weighting systems and lipreading: A comparative reappraisal. *Journal of the Academy of Rehabilitative Audiology, 13,* 5-15.

Jaffe, J., & Feldstein, S. (1970). *Rhythms of dialogue.* New York: Academic Press.

Jeffers, J., & Barley, M. (1971). *Speechreading (lipreading).* Springfield, IL: Charles C. Thomas.

Jonides, J., & Mack, R. (1984). On the cost and benefit of cost and benefit. *Psychological Bulletin, 96,* 29-44.

Kaplan, I.L., Bally, S.J., & Garretson, C. (1985). *Speechreading: A way to improve understanding.* Washington, DC: Gallaudet University.

Keppel, G. (1973). *Design and analysis: A researcher's handbook.* Englewood Cliffs, NJ: Prentice-Hall.

Kricos, P.B., & Lesner, S.A. (1982). Differences in visual intelligibility across talkers. *Volta Review, 84,* 219-225.

Lansing, C.R., & Helgeson, C.L. (1995). Priming the visual recognition of spoken words. *Journal of Speech and Hearing Research, 38,* 1377-1386.

Lesner, S.A., & Kricos, P.B. (1981). Visual vowel and diphthong perception across speakers. *Journal of the Academy of Rehabilitative Audiology, 14,* 252-258.

Lesner, S.A., Sandridge, S.A., & Kricos, P.B. (1987). Training influences on visual consonant and sentence recognition. *Ear and Hearing, 8,* 283-287.

Levinson, S.C. (1983). *Pragmatics.* Cambridge, England: Cambridge University Press.

Levitt, H., Waltzman, S.B., Shapiro, W.H., & Cohen, N.L. (1986). Evaluation of a cochlear prosthesis using connected discourse tracking. *Journal of Rehabilitation Research and Development, 23,* 147-154.

Lind, C. (1996). *Effects of prior linguistic context on sentence-based speechreading by adults with acquired hearing loss.* Unpublished master's thesis, LaTrobe University, Bundoora, Victoria, Australia.

Lyxell, B., & Rönnberg, J. (1987a). Guessing and speechreading. *British Journal of Audiology, 21,* 13-20.

Lyxell, B., & Rönnberg, J. (1987b). Necessary cognitive determinants for speechreading skills. In J.G. Kyle (Ed.), *Adjustment to acquired hearing loss* (pp. 48-54). Bristol, England: Centre for Deaf Studies, University of Bristol.

Miller, L.A. (1977). The effect of facial expressions on speechreading performance. In K.W. Berger (Ed.), *Research studies in speechreading* (pp. 14-18). Kent, OH: Herald Publishing House.

Nofsinger, R.E. (1991). *Everyday conversation.* Newbury Park, CA: Sage.

Pelson, R.O., & Prather, W.F. (1974). Effects of visual message-related cues, age, and hearing impairment on speechreading performance. *Journal of Speech and Hearing Research, 17,* 518-525.

Popelka, G.R., & Berger, K.W. (1971). Gestures and visual speech perception. *American Annals of the Deaf, 116,* 424-436.

Rönnberg, J., Ohngren, G., & Nilsson, L.-G. (1982). Hearing deficiency, speechreading and memory functions. *Scandinavian Audiology, 11,* 261-268.

Rönnberg, J., Ohngren, G., & Nilsson, L.-G. (1983). Speechreading performance evaluated by means of TV and real-life presentation. *Scandinavian Audiology, 12,* 71-77.

Schiavetti, N., Sitler, R.N., Metz, D.E., & Houde, R.A. (1984). Prediction of contextual speech intelligibility from isolated word intelligibility measures. *Journal of Speech and Hearing Research, 27,* 623-626.

Smith, R.C., & Kitchen, D.W. (1972). Lipreading performance and contextual cues. *Journal of Communication Disorders, 5,* 86-90.

Stanovich, K.E., & West, R.F. (1981). The effect of sentence context on ongoing word recognition: Tests of a two-process theory. *Journal of Experimental Psychology: Human Perception and Performance, 7,* 658-672.

Stanovich, K.E., & West, R.F. (1983). On priming by a sentence context. *Journal of Experimental Psychology: General, 112,* 1-36.

StatView SE + Graphics [Computer software]. (1989). Berkeley, CA: Abacus Concepts.

Tye-Murray, N. (1994). Communication strategies training. In J.-P. Gagné & N. Tye-Murray (Eds.), *Research in audiological rehabilitation: Current trends and future directions* [Monograph]. *Journal of the Academy of Rehabilitative Audiology, 27,* 193-207.

Walden, B.E., Erdman, S.A., Montgomery, A.A., Schwartz, D.M., & Prosek, R.A. (1981). Some effects of training on speech recognition by hearing-impaired adults. *Journal of Speech and Hearing Research, 24,* 207-216.

Walden, B.E., Prosek, R.A., Montgomery, A.A., Scherr, C.K., & Jones, C.J. (1977). Effects of training on the visual recognition of consonants. *Journal of Speech and Hearing Research, 20,* 130-145.

APPENDIX

LIST OF THE 40 SENTENCE PAIR STIMULI

Key words for scoring are underlined in each stimulus sentence.

1. Unrel. Why didn't those people get wet in the rain?
   Rel. Why do you need new shorts?
   Stim. I broke the elastic in my old pair.

2. Unrel. Why can't your friends join us tonight?
   Rel. Why does your aunt want to buy a puppy?
   Stim. She wants a pet to keep her company.

3. Unrel. Why were your friends ready to leave before breakfast?
   Rel. Why is that child standing on the chair?
   Stim. She can't reach the top shelf by herself.

4. Unrel. Why is your daughter repeating her studies?
   Rel. Why were your friends ready to leave before breakfast?
   Stim. They wanted to start their trip early.

5. Unrel. Why does your aunt want to buy a puppy?
   Rel. Why haven't you finished painting the bedroom?
   Stim. We're waiting for the undercoat to dry.

6. Unrel. Why is your neighbor staying home today?
   Rel. Why do you have the lamp on?
   Stim. We need more light in this room.

7. Unrel. Why have you put your overalls on?
   Rel. Why did your mother go to the bank?
   Stim. She didn't have enough money to go shopping.

8. Unrel. Why is your brother so tired and hungry?
   Rel. Why are you suddenly interested in sculpture?
   Stim. I read an interesting book on it recently.

9. Unrel. Why were you so late for work this morning?
   Rel. Why is your daughter repeating her studies?
   Stim. She failed her exams last year.

10. Unrel. Why did your mother go to the bank?
    Rel. Why did you lay carpet in the hall?
    Stim. We found the wooden floor was too noisy.

11. Unrel. Why are you suddenly interested in sculpture?
Rel. Why is your brother so tired and hungry?
Stim. He spent all night lost in the snow.

12. Unrel. Why is that child standing on the chair?
Rel. Why are your parents selling their house?
Stim. They have decided to move to the country.

13. Unrel. Why have you made a doctor's appointment?
Rel. Why weren't the children home when I called?
Stim. They were playing in the park all afternoon.

14. Unrel. Why does your brother get up so early?
Rel. Why are you walking around in bare feet?
Stim. I can't find my shoes and socks anywhere.

15. Unrel. Why did you lay carpet in the hall?
Rel. Why do your parents visit so often?
Stim. They like to spend time with the family.

16. Unrel. Why have you applied for unemployment benefits?
Rel. Why didn't those people get wet in the rain?
Stim. They ran for cover when the storm began.

17. Unrel. Why do you have the lamp on?
Rel. Why can't your friends join us tonight?
Stim. They couldn't find a baby sitter.

18. Unrel. Why wasn't that man invited back again?
Rel. Why have you applied for unemployment benefits?
Stim. I can't find work anywhere.

19. Unrel. Why haven't you finished painting the bedroom?
Rel. Why is your friend sweating so much?
Stim. She rode her bicycle to the park and back.

20. Unrel. Why does your wife like inviting her family over?
Rel. Why have you made a doctor's appointment?
Stim. I haven't been feeling very well.

21. Unrel. Why do your parents visit so often?
Rel. Why are you standing at the front gate?
Stim. I'm waiting for the mail to arrive.

22. Unrel. Why does that man look so shocked?
Rel. Why do your in-laws both look so healthy?
Stim. They play golf together twice a week.

23. Unrel. Why does your sister need so many check-ups?
Rel. Why is your neighbor staying at home today?
Stim. He is waiting for his fridge to be delivered.

24. Unrel. Why weren't the children home when I called?
Rel. Why does that man look so shocked?
Stim. He can't believe the bad news.

25. Unrel. Why are you standing at the front gate?
Rel. Why does your wife like inviting her family over?
Stim. She enjoys cooking meals for them.

26. Unrel. Why is your brother behind in his studies?
Rel. Why have you put your overalls on?
Stim. I'm working on the car this afternoon.

27. Unrel. Why isn't your son home for dinner?
Rel. Why does your sister need so many check-ups?
Stim. She was very sick during the winter.

28. Unrel. Why didn't you answer the phone?
Rel. Why is your brother behind in his studies?
Stim. He hasn't been doing his homework.

29. Unrel. Why are you looking under the bed?
Rel. Why isn't your son home for dinner?
Stim. He took some friends to the theater.

30. Unrel. Why are your parents selling their house?
Rel. Why is your daughter excited about this evening?
Stim. She has a date with her new boyfriend.

31. Unrel. Why are the neighbors going out so late?
Rel. Why wasn't that man invited back again?
Stim. He bored the audience with his long-winded speech.

32. Unrel. Why is your daughter excited about this evening?
Rel. Why didn't you answer the phone?
Stim. We were in the kitchen and didn't hear it.

33. Unrel. Why does your mother get angry at him?
Rel. Why are the neighbors going out so late?
Stim. They are meeting a friend at the airport tonight.

34. Unrel. Why are you walking around in bare feet?
Rel. Why did your friend want you to help him?
Stim. He couldn't lift the bookshelf by himself.

35. Unrel. Why is your friend sweating so much?
Rel. Why are you looking under the bed?
Stim. I've lost one of my sandals.

36. Unrel. Why do you need new shorts?
Rel. Why does your brother get up so early?
Stim. He leaves for work at about seven-thirty.

37. Unrel. Why is your brother calling the repairman?
Rel. Why were you so late for work this morning?
Stim. I didn't hear the alarm go off.

38. Unrel. Why did your friend want you to help him?
Rel. Why are you leaving so early?
Stim. I'm going out for dinner tonight

39. Unrel. Why do your in-laws both look so healthy?
Rel. Why does your mother get so angry at him?
Stim. He always leaves his clothes on the floor.

40. Unrel. Why are you leaving so early?
Rel. Why is your brother calling the repairman?
Stim. He doesn't know how to fix the washing machine.

Note. Unrel. = unrelated question; Rel. = related question; Stim. = stimulus sentence.