SIGN RECOGNITION PROCESSES IN AMERICAN SIGN LANGUAGE: THE EFFECT OF CONTEXT*

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The effect of context on sign-recognition processes in American Sign Language (ASL) was studied by means of the gating paradigm (Grosjean, 1980). Individual signs were presented in two different conditions: a context condition in which signs were preceded by a context, and a no-context condition in which they were excised from the signing stream. A strong context effect was found: signs were isolated sooner in context, perfect confidence in the response was reached earlier, and the candidates proposed before the isolation point reflected a narrowing-in process that was both semantic and phonological. Future research in sign recognition and models of lexical access are discussed in light of these findings.

Very little is known about the process of lexical access in American Sign Language (ASL). To our knowledge, only a single study has touched on this topic (Grosjean, Teuber, and Lane, 1978), and this study was actually designed to examine another question, the subjective onset of signs. However, the results obtained by Grosjean *et al.* have been re-analyzed and interpreted in terms of sign recognition (Grosjean, 1981), and they will serve as a base for the present study.

Grosjean *et al.* (1978) presented individual signs to subjects by means of the gating procedure. This consists in showing a sign a number of times and increasing its presentation time (as measured from the sign onset) at each successive pass. The subject's task is to guess the sign after each pass and to rate his or her confidence in the guess. (For more information on the gating paradigm, see Grosjean (1980, 1981); for earlier versions of the paradigm see Pollack and Pickett (1963), and Öhman (1966)). Results showed that on the average only half of the sign was needed to isolate it, that is, to guess it correctly and without subsequently changing the guess. In addition, Grosjean (1981) found that five sign attributes affected the isolation times of a sign. They were the frequency of usage of the sign, the frequency of occurrence in signs of the sign's location type, the number of repetitions in the movement of the sign, the complexity of the sign

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(as defined by Battison, 1978) and the frequency of occurrence in signs of the sign's movement type. Further, the distance from the starting point of the sign (signer's hands on table top) to its articulation point appeared to have an effect on the time it took to isolate the sign.

An analysis of the confidence ratings given by observers at the isolation point of the sign and at the last presentation of the sign showed that signers reach the isolation point without having much confidence in their guesses, and that confidence increases from the isolation point to the end of the sign. Based on this, Grosjean (1981) suggested a two-stage process of recognition: first a sign is "isolated" or highlighted in a list of candidates and then, somewhat later, the candidate is "accepted"; it is at this point that one may say that the sign is fully recognized.

Grosjean also calculated the mean isolation time of each of four supposed formational parameters of a sign – the location, the orientation, the hand configuration (or handshape), and the movement of the sign. Using canonical-form signs and measuring from the release of a switch on a table top, he found that the correct location, orientation, and hand configuration of the stimulus were isolated at about the same time (307, 309, and 322 msec into the sign, respectively). It was some 70 msec later, however, that the correct movement was isolated and *ipso facto* that the correct sign was isolated. This three-plus-one pattern was substantiated by the fact that the only significant difference in isolation time was found between movement and each of the three other parameters. Further, an interaction between signs and parameters was obtained.

In an analysis of errors of the movement parameter, Grosjean found that signers tended to use certain movement "primes" (instances of the movement parameter) in preference to others. Kegl (personal communication) suggests that this results from a bias for hand-external movements (such as vertical, sideways, and horizontal) over hand-internal movements (such as twisting, nodding, bending, opening, closing, wiggling, and entering).

Grosjean *et al.* (1978) studied only canonical signs presented in isolation and did not seek to determine whether context affects the sign-recognition process, as it does in word recognition (Morton and Long, 1976; Marslen-Wilson and Welsh, 1978; Grosjean, 1980). In the present study, the signs analyzed by Grosjean *et al.* have been embedded in a context and presented either in context or excised from the contextual stream in a no-context condition. This will allow us to determine the impact of context on such factors as the isolation times of signs, the confidence ratings given by subjects, as well as the narrowing-in process that takes place prior to the isolation of the sign.

First, the isolation times of signs presented in and out of context will be studied. It is expected that these will be shorter for signs in context as subjects can make use of the syntactic, semantic, and prosodic information that is contained in the preceding context. This information is lacking in the no-context condition and therefore, subjects will need more bottom-up (visual) information before isolating the sign. (See Marslen-Wilson and Welsh (1978) or Marslen-Wilson and Tyler (1980) for a discussion of the interaction between top-down and bottom-up information during word recognition).

Second, the effect of context on the confidence ratings will be examined. It is expected that ratings at the isolation point will be similar in the no-context and the context conditions. The reasoning here is based on the following premise: in context observers have more top-down information (and hence can isolate a sign more quickly) but they have less bottom-up information at that point. This increase in one information source but decrease in the second information source is expected to produce opposing effects on confidence ratings and hence, reduce the difference in the two conditions. However, it is expected that less of the sign will be required for signers to reach perfect confidence (a rating of 10 on a 1-to-10 scale) in the context than in the no-context condition. It is only in this last respect that a context effect on confidence ratings is expected.

Third, the present study will examine the effect of context on the narrowing-in process through an analysis of errors. In the no-context condition, it is expected that formationally based errors, made prior to the isolation point, will occur during the narrowing in on both sign parameters and parameter primes (that is, instances of the parameter). In the context condition, however, it is expected that patterns of errors will be based on both the formation aspects of the sign and the semantic content of the sentences.

Finally, in addition to showing a context effect on sign recognition processes, a comparison of our findings in the no-context condition will be made to those of the earlier study (Grosjean *et al.,* 1978; Grosjean, 1981). A number of differences exist between the two studies: in the present study, signs in the no-context condition are extracted from their contextual stream, while in the prior study, the canonical form of the signs was used; in the present study, 100% of the sign is presented at the last gate, while in the prior study, 81% of the total sign, on the average, was presented because of the gating procedure used; finally, the present study requires signers to guess the target sign's identity at very early gates, while the prior study did not. Despite these differences, it is expected that quite similar trends in the two studies in terms of isolation points, confidence ratings, and patterns of sign narrowing-in will be obtained.

METHOD

Subjects

Ten deaf fluent signers (three female, seven male) of American Sign Language (ASL) were randomly assigned to two groups of five subjects each. One group was run in the context condition, while the other group was run in the no-context condition. Subjects were paid for their participation in the experiment.

Materials

Thirty-six of the 37 signs used by Grosjean *et al.* (1978) were embedded in an appropriate sign context. Thus, for example, the sign SEARCH appeared in the context

HAPPEN MY BROTHER FAULT LOOSE CAT SISTER *SEARCH* MUST[1]

[1] *Rather than use a transcription system for ASL here (e.g., Stokoe* et al., *1976), we have transliterated the contexts by substituting an English gloss for each sign. The choice of English glosses is somewhat arbitrary. Separate glosses represent separate signs, whereas hyphenated glosses represent a single sign.*

(English translation: It was my brother's fault that the cat got loose and my sister had to look for it.)

and the sign HOME appeared in

EVERY-NIGHT TIME SIX MY SISTER *HOME* TEND SHE

(English translation: My sister tends to arrive home every night at six o'clock.)

Every target sign was preceded by the sign SISTER in a contextually appropriate manner so that an identical starting point could be determined for the gating sequence (that is, the final contact of SISTER).

In order to determine the contextual constraint of the sentences used, a videotape was constructed in the following way. A fluent signer was recorded articulating the 36 contexts up to and including the stimulus sign (Sony VO-2611 videocassette recorder); he was also recorded articulating the 36 stimulus signs preceded by the sign SISTER (giving SISTER SEARCH, SISTER HOME, etc.) as well as sentences in which signs that were not part of the 36 were preceded by highly constraining contexts, as in

ARRIVE HOME DOOR LOCKED, CHECK POCKETS EMPTY SHUCKS, OCCUR-TO-ME HAVE EXTRA *KEY* AROUND CORNER

(English translation: When I arrived home the door was locked, so I checked my pockets which were empty – darn – then it occurred to me that I keep an extra key around the corner.)

These recordings were randomized and presented to six judges, all deaf fluent users of ASL, for estimates of constraint. Judges were given an answer sheet that contained the glosses of the contexts and the stimulus signs as well as a 1–10 scale where 1 was labelled "VERY LOW CONSTRAINT," and 10 "VERY HIGH CONSTRAINT." Judges were asked to look at each video tape sequence and to indicate how constraining they felt the context was on the sign underlined on the response sheet. To do this, they were told to circle a number between 1 and 10. Results gave a mean constraint value of 1.4 for signs in the no-context condition (that is, signs only preceded by SISTER), with a range of 1.0–3.3. A mean constraint value of 4.96 was obtained for signs in the context condition (that is, those preceded by a sentence), with a range of 1.8–7.3.

An original master videotape of a deaf fluent signer articulating the 36 ASL contexts was recorded, then a key copy of the original master was made. This key copy was viewed frame-by-frame by two independent judges. They were asked to identify (1) the first frame of the sentence, (2) the first frame of contact-break at the end of the sign SISTER, and (3) the last frame of the completed target sign. The judges nearly always agreed on the frame count of each of these points. The few exceptions showed agreement to within one frame.

The 36 target signs were excised from the original context and presented repeatedly at increasing durations. The number of trials for each sign differed due to the differing durations of the target signs. The first gate of each set consisted of the last three frames of SISTER and the first frame of contact-break following SISTER. Each frame was 33.33 msec in duration. Thus, the first gate was four frames or 133.33 msec long. The second gate consisted of the same four frames presented in the first gate plus one additional frame (five frames long). The gates increased in duration by one frame at each successive presentation. This continued until the sign had been presented in full.

The same articulations of the 36 target signs were also gated in their sentential contexts. The preceding context was presented repeatedly followed by the gated target sign. The first gate consisted of the preceding context and the first frame of contact-break following the sign SISTER. Each successive presentation contained the same information as the preceding gate plus one additional frame. This continued until the complete sign had been presented.

Procedure

The gated videotapes were played on a Sony VO-2611 U-Matic video cassette recorder/ player. A Sony CVM-110 nine-inch monitor was used for display to the subjects.

Subjects were run in individual sessions in both the no-context and context conditions. Instructions were signed to the subject in ASL by a prelingually deaf research assistant. Subjects were required to guess what sign was being presented after each gate and to assign a confidence rating to their guess. A rating scale from 1 (very unsure) to 10 (very sure) was explained, and exemplified. Further, the nature of the stimuli was explained. Subjects were told that they would see only a small portion of the stimulus at first and then more and more of it, until it was completely shown. They were asked to feel free to change their guesses from trial to trial.

The subjects' guesses were transcribed using the gloss of a sign, and/or using Stokoe notation (Stokoe, Casterline, and Croneberg, 1976) by the prelingually deaf research assistant. All responses were given in ASL.

Data analysis

The transcription records yielded the duration of the gate at which each signer correctly guessed the target sign and did not subsequently alter his or her guess. This duration is called the isolation point (Grosjean, 1980). The percentage of the way through a sign required to reach the isolation point was calculated and used in subsequent analyses to control for the differing durations of signs in this and in the first study (Grosjean *et al.,* 1978; Grosjean, 1981).

The transcription records also yielded the signers' confidence ratings at the isolation point as well as the sign's duration at the gate at which each signer reported perfect confidence (that is, 10 on the scale). The latter (durations) were used to calculate the percentage of the way through a sign required for signers to report perfect confidence.

Erroneous guesses made by signers up to the isolation point were obtained from the transcription records and tabulated as sign candidates. These "errors" were further analyzed and tabulated for their parameter and prime values.

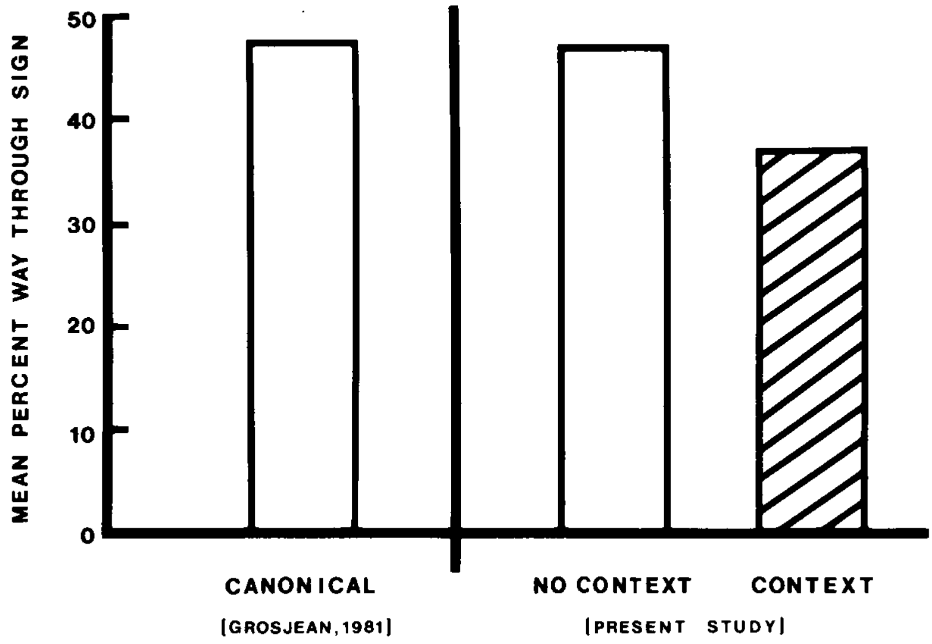

Fig. 1. Amount of a sign (expressed as a mean percentage of the way through the sign) required to isolate it when presented in its canonical form (Grosjean, 1981), excised from the signing stream (no context), and presented in the signing stream (context). Each bar is based on the mean of 36 signs.

Correlated t tests were used to test for differences in percentage of the way through to reach the isolation point in the canonical (Grosjean, 1981) versus the no-context condition, and in the context and no-context conditions. Such a test was also used to test for differences in confidence ratings at the isolation point and for differences in the amount of a sign needed to reach perfect confidence (10).

Sign, parameter, and prime candidates were graphically plotted to reveal the narrowing-in processes for each of them. The parameter data further lent themselves to a 2 × 4 analysis of variance of context by parameters, where context and parameters were fixed effects. A Tukey HSD was used to break down the main effect for parameters.

Results and Discussion

Isolation points

Figure 1 presents the amount of a sign required to isolate it in each of the three conditions: canonical (Grosjean, 1981), no-context, and context. No difference was found between the canonical condition and the no-context condition (47.7% and 47.1%, respectively; t = 1.08, N.S.). This replication of Grosjean's results is interesting in light of the differences between the two studies, especially in the nature of the signs: they were excised out of the signing stream in the present study but were presented in their canonical form in the previous study. The differences between the two studies, however, were not sufficient to alter the amount of a sign needed to isolate it.

Of more interest is the actual percentage of a sign needed to reach its isolation point. Why is it that an observer only needs about half the sign to isolate it whereas a listener needs some 80% of a spoken word (Grosjean, 1980)? Part of the answer may lie in the more parallel nature of the "phonetic" or formational structure of the sign (see Stokoe, 1960, for instance). This information may be presented in a more simultaneous manner in sign than are phonemes and syllables in speech. However, this proposal can be debated (Studdert-Kennedy and Lane, 1980), and one will therefore need further research in sign and word recognition to explain this difference.

A comparison of the amount of a sign needed to isolate it in the no-context and the context conditions reveals a marked difference, as can be seen in Figure 1. The mean percentage of the way through a sign needed to reach isolation are 47.1 and 37.7, respectively ($t = 4.05$, $p < 0.01$). The standard deviations are 17.1 and 14.5, and the percentages range from 23 (PERFECT) to 79 (BLACK), and from 17 (RUN) to 59 (BUG), respectively. The context effect can be exemplified with the sign COW. In the no-context condition 66% of the sign was needed on the average for signers to isolate it while in the context condition (FARM THERE SHARE TAKE-CARE ANIMAL, MY BROTHER GOAT, ME HORSE, SISTER COW ALL ENJOY; English translation: At the farm over there we share taking care of the animals; my brother cares for the goat, I care for the horse, my sister cares for the cow and we all enjoy it), only 34% of the sign was needed to isolate it. It should be noted that had the constraints preceding the stimulus signs been stronger, we would most likely have obtained even earlier isolation points. (See Grosjean (1980) for a manipulation of the context preceding a spoken word).

Sign attributes such as sign frequency and sign complexity, previously studied by Grosjean (1981), were used to run a multiple regression analysis on the no-context and context conditions. The aim behind this was to obtain some further confirmation of the effect of context – in this case, that context reduces the overall effect of the attributes of a sign. The multiple Rs obtained with eight predictor variables were 0.69 for the no-context condition and 0.59 for the context condition. This means that the total variance accounted for by the attributes of a sign drops by more than half – from 32% to 14% as revealed by the adjusted R^2s – when one goes from the no-context condition to the context condition.

This drop in total variance accounted for by the sign attributes would seem to indicate that the observer's dependence on the physical attributes of the stimulus weakens in context. This is consistent with interactive theories of lexical access. Such theories postulate that various sources of knowledge can operate during the recognition process. A preceding context could contain information about the target's part of speech, its meaning, its stress pattern, etc. If, in context, these other sorts of information are interacting with bottom-up information during the recognition process, one would expect a weakened dependence on bottom-up attributes. This is in fact what was found in this study.

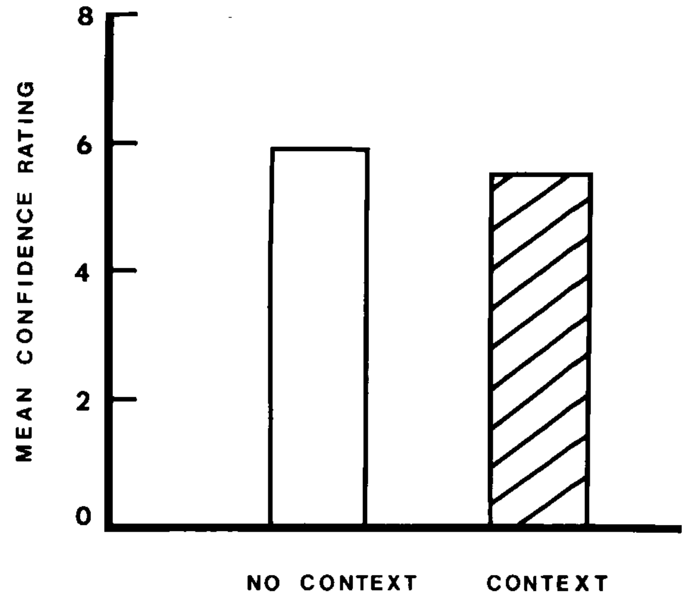

Fig. 2. Mean confidence rating at the isolation point in the no-context and context conditions. Each bar is based on the mean of 36 signs.

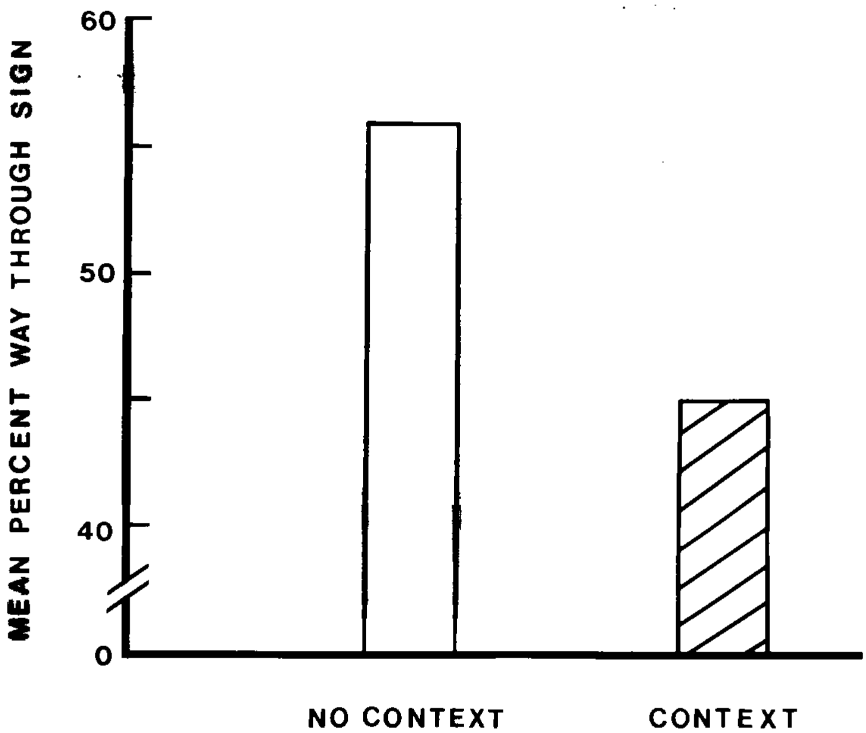

Fig. 3. Amount of a sign (expressed as a mean percentage of the way through the sign) required to reach a confidence rating of 10 (perfect confidence) in the no-context and context conditions. Each bar is based on the mean of 36 signs.

From all this it can be concluded that context has a rather strong effect on the amount of a sign required to reach the isolation point. This finding is in line with the many studies that have found context effects in other languages, other modalities, and using other experimental tasks (Morton and Long, 1976; Schuberth and Eimas, 1977; Marslen-Wilson and Welsh, 1978; Foss and Blank, 1980; Grosjean, 1980).

Confidence ratings

A comparison of the confidence ratings at the isolation point in the canonical and the no-context conditions showed that they were similar: 5.95 and 5.87, respectively (t = –0.15, N.S.). As with the isolation data, therefore, the no-context condition in this study replicates Grosjean *et al.*'s (1978) canonical form experiment.

Figure 2 presents the mean confidence ratings at the isolation point for signs presented in no-context and in context. In the no-context condition, the mean rating was 5.87 and in context it was 5.47 (t = 1.35, N.S.). It is interesting that in context, where top-down information is available, the confidence ratings are similar to those of the no-context condition. However, as proposed earlier, subjects are correctly guessing the target much earlier in the context condition and are doing so with less bottom-up information. This reduced information counterbalances the effect of the top-down information and leads to equal confidence ratings.

The role of context during sign recognition can be reflected by the confidence ratings, but only *after* the isolation point. Figure 3 presents the amount of a sign required to reach a confidence rating of 10 (that is, perfect confidence), in the no-context and the context conditions. As can be seen, observers need more of the sign in no-context than in context to feel perfectly confident about their guess: 56% as compared to 45% of the sign (t = 5.5, p < 0.01). This result shows once again that sign recognition takes place faster in context than out of context. Whether actual sign recognition occurs at the isolation point or some time later – when a certain level of confidence is reached as Grosjean (1981) would argue – both the isolation-point data and the confidence-rating results indicate a strong context effect. Current models of word recognition, such as Morton's (1969) logogen model or Marslen-Wilson and Welsh's (1978) cohort model, take this effect into account and predict earlier recognition of words in context. Sign recognition models will also have to account for faster recognition of signs in context.

The sign-isolation process

Grosjean (1980) used an analysis of erroneous guesses made by subjects up to the isolation point to examine the process whereby listeners arrived at the correct guess in a spoken-word gating paradigm. The sign-isolation process is examined in this study using analyses of candidates in three ways. First, a context effect will be shown by examining the sign candidates proposed in the two context conditions. Second, a parameter-by-parameter narrowing in will be shown by examining the amount of a sign required to isolate each of the four formational parameters (parameter candidates) in the two context conditions. Third, the narrowing in on primes (specific values of each parameter) will be exemplified by examining the narrowing in on the location prime

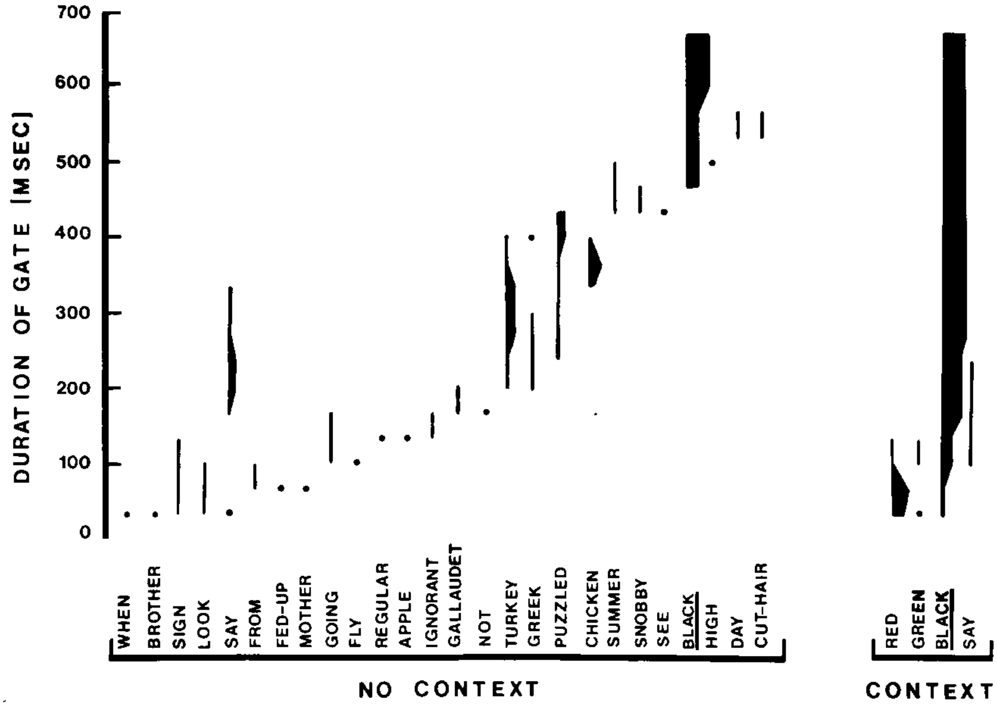

Fig. 4. Sign candidates proposed at each gate for the target sign BLACK in the no-context and context conditions. Candidates proposed at only one-gate duration are depicted with a dot; those proposed over two or more gates are depicted by continuous lines. The number of subjects proposing a particular candidate is represented by the thickness of the line – the more subjects, the thicker the line.

(prime candidates) in a particular sign.

Sign candidates. Figure 4 presents the sign candidates proposed at each of the gates for the target BLACK when presented in no-context and in context. Candidates that were proposed only once are represented by a dot. Those proposed over two or more gates are represented by vertical lines. The number of subjects proposing a candidate is represented by the thickness of the line. The more subjects proposing a candidate, the thicker the line.

The most striking aspects of this figure are that the sign BLACK is isolated later in the no-context condition, and that the number of different candidates in this condition is much greater than in the context condition. A finer grain comparison of the two conditions reveals a number of interesting contrasts. In no context 28 different signs were proposed over the trials, while only four different signs were proposed over the trials in context. In no context, of the first five guesses, none were color names; while in context, of the first five guesses, all were color names. In no context it is not until the fourteenth gate that BLACK is first proposed; while in context it is at the first gate that BLACK is

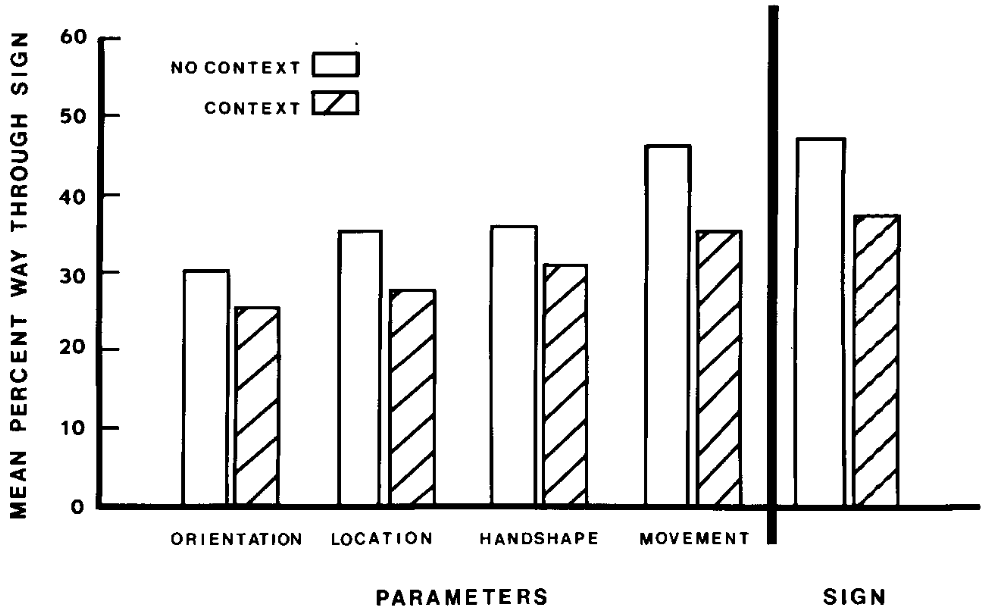

Fig. 5. Amount of a sign (expressed as a mean percentage of the way through the sign) required to isolate each of the four formational parameters (orientation, location, handshape, and movement), in both the no-context and context conditions. To the right has been added the amount of the sign needed for correct isolation. Each bar is based on an *n* of 36.

first proposed. In no context, subjects seem to be relying on visual information, and a phonological narrowing in is taking place; indeed this is the only possible strategy. In context, three of the four different guesses are color names and the fourth (SAY) fits the ASL context (MY FAVORITE COLOR WHITE, BROTHER BLUE, SISTER . . .; English translation: My favorite color is white, my brother's is blue, my sister ('s is *black*) (*says* we're both crazy).). Thus, a phonological and semantic narrowing in is taking place in context. It is especially interesting to note that in context the information provided by the carrier context is having its effect by the end of the first gate. This pattern is found in all of our signs presented in and out of context: narrowing in is bottom-up (phonological or formational) in the no-context condition, but is both bottom-up and top-down in the context condition. Top-down information in this case is syntactic, semantic, prosodic, and even pragmatic.

Parameter candidates. Figure 5 presents the amount of a sign required to isolate each of the four parameters (orientation, location, handshape, and movement) in the no-context and the context conditions. On the right of the figure, the mean isolation data for the sign itself have been added (see Figure 1).

Grosjean (1981) performed an analysis of variance on his canonical signs data. He found a main effect for parameters and when he broke it down (Tukey HSD; Kirk, 1968) he observed that the only significant difference among the parameters was between movement and each of the three other parameters (these latter three did not differ significantly from each other). Grosjean took this to imply that the orientation, location, and handshape of a sign are isolated at about the same time; it is only some time later that the movement parameter is isolated. Movement is therefore the "clincher" parameter that enables the observer to isolate the sign.

In order to replicate these findings, the no-context data in the present study were used in an analysis of variance which was modelled on Grosjean's (1981) analysis. Here too, a significant main effect was obtained for parameters ($F'(3, 67) = 28.04, p < 0.01$). An a posteriori test (Tukey HSD; Kirk, 1968) revealed the same three-plus-one pattern as the earlier study. That is, movement differed significantly from the three other parameters, while the latter three did not significantly differ from each other. The present study's no-context condition data thereby replicated Grosjean's earlier (1981) findings.

The data from both context conditions were then used in a 2 × 4 (context by parameters) analysis of variance. A main effect was obtained for context ($F(1, 31) = 5.39$, $p < 0.05$) again showing that signs are isolated more quickly in the context condition. A main effect was also obtained for parameters ($F'(3, 41) = 37.51, p < 0.01$). An a posteriori test (Tukey HSD; Kirk, 1968) showed that the only significant difference between the parameters (collapsed across contexts) was again between movement and each of the other three parameters, while the latter three did not significantly differ from each other (the same three-plus-one pattern observed in the one way ANOVA above). Further, no significant interaction was found between context and parameters ($F'(3, 47) = 1.86$, N.S.) indicating that the effect of context is similar for all four parameters.

Given these results, two conclusions can be drawn. First, a two-stage process of parameter narrowing in is apparently supported. Initially, the orientation, location, and handshape of a sign are isolated, and then somewhat later, the movement parameter is isolated; this last parameter "triggering" the isolation of the sign. Second, context is shown to have a role at the level of the parameters (as would be expected); top-down information is allowing the observer to narrow in on the sign more quickly and hence not to have to rely as much on bottom-up information.

Prime candidates. This study was not designed to analyze the prime candidates proposed by signers over trials and hence problems arise when this is attempted. (Prime candidates are, for example, those values of a parameter, say location, such as chin, neck, nose, etc. or those of movement, such as away, toward, up, down, etc. which are a specific realization of a parameter value used in a sign.) One of the problems is the constraint real signs place on the responses subjects make. Not all possible combinations of primes form real signs (as not all possible combinations of phonemes form real words) and hence when an error is made by a subject before the isolation point, it may well be quite different from the stimulus presented. This difference, however, may only reflect the fact that no signs exist in the immediate formational vicinity of the stimulus sign and therefore the observer is forced to choose a sign that is formationally quite removed. A second problem is that sign frequency will likely have an effect both on the signs that are proposed and on the order in which they are proposed. The solution to these problems would be to design an experiment using nonsense signs. It would then be easier

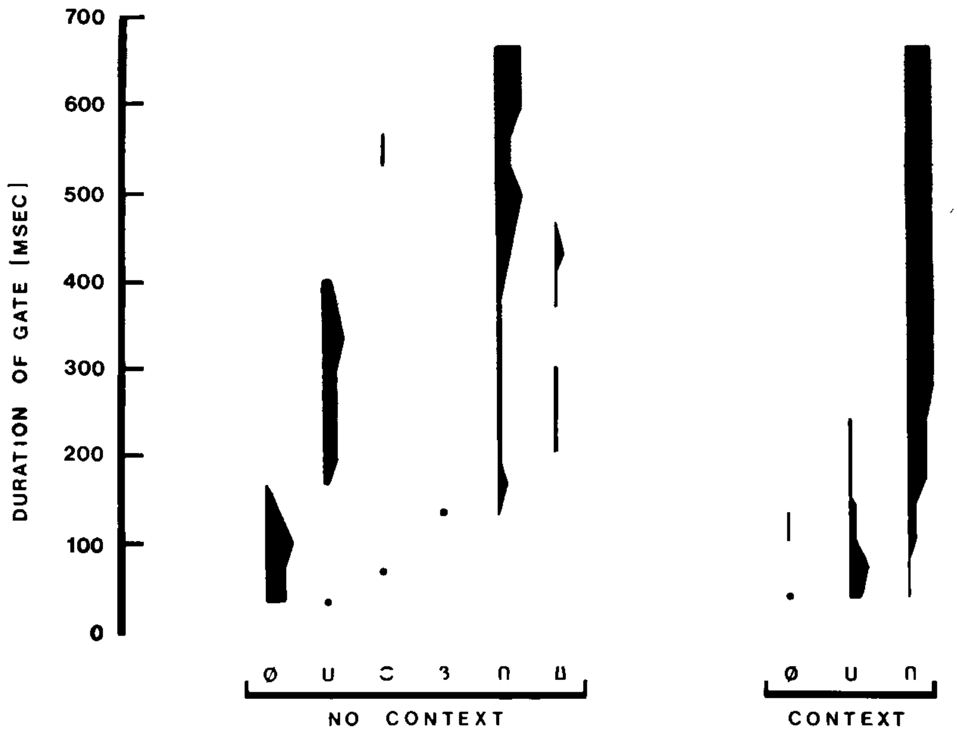

Fig. 6. Location primes proposed at each gate for the target sign BLACK in the no-context and context conditions (see Figure 4); ∅ = neutral space; ∪ = chin; ⊂ = face, or whole head; 3 = cheek; ∩ = forehead; ⊔ = mid-face.

to study the phonological narrowing in on each of the parameters (at least in a no-context condition).

An indication of the type of results that could be obtained from such a study is shown in Figure 6. Here the prime candidates for the location parameter of the sign BLACK in the no-context and context conditions are presented. The sign that preceded BLACK was SISTER, which is articulated in neutral space, whereas BLACK is articulated on the forehead. At the early gates in the no-context condition, locations such as lower or upper neutral space tend to be used. These locations are the same as, or are spatially close to, the location of the preceding sign SISTER. At intermediate gates, locations such as chin and cheek tend to be used. These locations are intermediate between the neutral location of SISTER and the forehead location of BLACK. At the later gates, whole face and nose locations, which are close to the location of the target location (forehead), are being used. It would appear that signers are using the location of the hands at the end of the gate as well as trajectory information to narrow in on the location of the target sign.

It is interesting to note how different the pattern is in context. Instead of a slow progression toward the forehead location, one can see an immediate narrowing in on the chin/mouth area where many color signs are articulated (recall the preceding context was MY FAVORITE COLOR WHITE, BROTHER BLUE, SISTER . . .). This location drops out, however, as soon as observers realize that the hand is moving further up. They then propose the forehead location (leaving out intermediary locations), as it is the only location above the chin/mouth location that is used for the articulation of a color sign. Also, the handshape and the orientation are interacting with the semantic information to cue the observer to the forehead location.

CONCLUSION

The present study replicated a number of findings obtained in a prior study (Grosjean, *et al.,* 1978; Grosjean, 1981), even though the stimuli were presented in their canonical form in that study but excised from the signing stream here. First, about half the sign was required to isolate it; second, a medium level of confidence was obtained at the isolation point; and third, the same three-plus-one pattern of correct usage of parameter values was found, with the movement parameter being isolated last.

In addition, the present study showed a strong effect of context on the sign-recognition process. First, the amount of a sign required to isolate it was reduced in context; second, less of a sign was needed to attain perfect confidence; and third, context affected the number and kind of candidates proposed by subjects. Further, the present study showed that the three-plus-one pattern of correct usage of parameter values held true in context – the movement parameter was still isolated later than the other three parameters in the signers' guesses.

This study is an early step toward an understanding of the processes that underlie sign recognition. A host of interesting questions remain unanswered. For instance, the present study did not manipulate sign attributes as independent variables. It would be of interest to determine whether a parametric study of context, sign frequency, and sign complexity would yield main effects for all three factors as well as interactions such as frequency by context (as found in word recognition). A study is currently under way to investigate this. An additional question is whether the results obtained using the gating paradigm are specific to the paradigm or not. For example, one might expect different patterns of relative parameter recognition using different paradigms. Using gating, movement is the last parameter to be used correctly. This is a reasonable result considering that movement is time-dependent information, and that at early gates movement information is largely missing. However, using a signal-to-noise manipulation or in a digitized signal, manipulating the sampling rate (i.e., making the picture less and less "blocky" at successive presentations), one could expect handshape to be the last correctly used parameter. While the entire movement would be presented at each pass, at early gates the picture would be difficult to see clearly. This might allow an observer to determine the movement value but not to determine finer distinctions, such as which handshape was being used. On the other hand, one would not expect the main effects such as the context effect to disappear as a result of changing the paradigm used. A comparison of the results across the two paradigms should allow us to determine which aspects of the results are paradigm-specific and which are related to the lexical access process itself. Therefore, a digitized sampling rate manipulation counterpart to the above mentioned parametric gating study is also being run. A third remaining question pertains to the recognition of inflected and derived signs compared to the recognition of their base forms. The verb OPPOSE, from which the noun ENEMY is derived, and which can be inflected as the plural noun ENEMIES, might be recognized by processes similar to or differing from those used to recognize the derived and inflected forms. This issue can also be addressed to word recognition in highly inflected spoken languages such as Navaho and Turkish. The extension of lexical-access research to highly inflected languages should prove extremely useful in deepening our understanding of the recognition process, whatever the structure of the language.

A final question pertains to sign-recognition models. Researchers in sign recognition will have to work within the framework of a general (cross modal) model of lexical access. Current models for spoken-word recognition (Morton, 1969; Forster, 1976; Marslen-Wilson and Welsh, 1978) could be modified and extended to account for results obtained from sign-recognition studies. Such models would contain characteristics that are common to speech and sign: the interaction of top-down and bottom-up information, the narrowing-in process on candidates, the possible two-stage approach to recognition as proposed by Grosjean (1980, 1981). These models would also have modality specificities, such as the initial acoustic-to-phonetic mapping processes for words and the visual-to-phonetic (formational) mapping in sign, as well as specific word and sign attributes that play a role in lexical access. Such models cannot be proposed, however, until more is known about the sign-recognition process. The present study was aimed at contributing to this growing knowledge.

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