Formal Representation of Interrogation in French Sign Language

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Abstract

This paper concerns the marking of interrogation in French Sign Language (LSF). Early work on Sign Languages (SLs) underlined the role of non-manual elements in the production of interrogatives. Studies often point to the role of eyebrows depending on the type of question: eyebrows would usually be raised for the production of yes/no questions, while they would be lowered for other types of questions. For LSF, previous studies seem to validate this contrast. We tested this thoroughly in the framework of AZee, a formal approach to SL modeling based on the identification of linguistic associations between forms and identified meanings, called *production rules*. We present our methodology to extract *AZee production rules*, consisting of data searches alternating form and meaning criteria gradually converging to strong associations, ultimately leading to production rules. Our results (i) show no link between raised or lowered eyebrows and a specific type of question, (ii) highlight instead the role of another non-manual marker: the advancement of the chin. However, since eyebrows remain frequently involved in the analyzed questions (all types included), we intend to further focus on the potential role of the signer's expectations while formulating his request.

Keywords: Sign language, Formal representation, Interrogation, Non-manual markers, LSF, SL Synthesis, AZee

1. Introduction

This article deals with a specific problem: interrogatives in French Sign Language (LSF), hitherto unaddressed through a formal approach. However, this phenomenon is essential if one wants to generate dialogues in Sign Language (SL), particularly in the case of signing avatars.

Current approaches to describe SLs formally are often elaborated from spoken languages, which are linear systems (see Hadjadj, Filhol, and Braffort (2018) for a review of existing systems). This may pose some fundamental problems since SLs are multi-linear visual-gestural languages. In contrast, the AZee model aims at integrating all the forms and phenomena observable in SL (Filhol, 2008, 2021). It is a corpus-based approach that defines systematic links between observed forms and interpreted meanings. It allows a formal representation of SL utterances. Our general goal is to extend the LSF coverage with AZee.

The following section (section 2) gives an overview of claims from previous studies on the topic of interrogatives for SL, and more specifically for LSF. We briefly present the basics of AZee approach and the methodology to enrich its system in section 3, after what we introduce the data we analyzed, and detail the application of the methodology on the data (section 4). Then, we show how our results confirm previous claims in literature and generate a way to cover interrogatives with AZee (section 5). Finally, we discuss the contribution of this work (section 6) and we propose some direction for future studies (section 7).

2. Interrogatives in Sign Languages

The relevant literature underlines the role of non-manual elements in the production of interrogatives in SLs ((Neidle et al., 2000) for American SL, ASL; (Coerts, 1990; Klomp, 2021) for Dutch SL, NGT; (Sutton-Spence and Woll, 1999) for British SL, BSL; or (Dubuisson et al., 1991) for Quebec SL, LSQ; see also (Cecchetto, 2012) for a review of previous work on several SLs). Most of these studies establish the role of different non-manual markers depending on the type of question. In these studies, the eyebrows seem to be raised and the head in a forward position for the production of so-called closed questions,[1] while the eyebrows would be lowered for the production of so-called open questions.[2]

However, since the beginning of the interest for this subject, some authors have pointed out the complexity of this phenomenon. Firstly, sometimes this dichotomy does not always seem so obvious (Baker and Cokely, 1980; Dubuisson et al., 1991). Secondly, non-manual elements can combine with other markers that have nothing to do with questioning, for instance, emotions (Weast, 2008, 2011; de Vos et al., 2009). Additionally, less studied SLs could display a slightly less marked pattern (Zeshan, 2004; Cañas Peña, 2019).

The only recent publication dealing with LSF,

[1] Closed questions: questions to be answered with "yes" or "no" (e.g. in English, "Is he coming tonight?").

[2] Open questions: questions that can't be answered with a simple "yes" or "no" (e.g. "What is your name?").

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(Sallandre et al., 2021), is based on a previous grammar of LSF that is widely used in teaching (Moody, 1983). It tends to validate the formal opposition between closed-ended and open-ended questions.

Finally, when it comes to SL avatar animation, it is often based on SL linguistics, which provides organization rules for animation data. Thus, the distinction between types of questions seems to be used also in this domain (McDonald et al., 2017).

3. The AZee approach

Since we chose AZee approach, here is a summarized presentation of its main principles. Then, we explain the corpus-based methodology to enrich the existing AZee system.

3.1. Production rules

AZee is a formal approach to SL modeling. It depends on identified linguistic associations between observable forms (i.e. timed body articulations) and identified meanings, for instance "pretty, beautiful". These associations are called *production rules*, and are generally given a name. For instance in LSF, production rule `pretty` associates the meaning "pretty, beautiful" with the form given in Figure 1.

Production rules can be parameterized with named arguments, which can be mandatory or optional (Hadjadj et al., 2018). For instance, the rule `pretty` has no argument. In contrast, the rule `inter-subjectivity` which supports meaning "everybody agrees on *sig*" has one argument named *sig*, which represents the object of agreement. The associated form is a lip pout produced over the form of *sig*.[3]

Combining our two example rules, the following expression composes the meaning: "everybody agrees that [it is] beautiful":

```
:inter-subjectivity
    'sig
    :pretty
```

Combining the associated forms results in fine detail synthesis and articulation synchronisation (Filhol and McDonald, 2018, 2020). Such *discourse expressions* can build up to arbitrary size, reflecting both the signed forms to be produced and the meaning to be interpreted from them.

The set of all production rules found for a given SL constitutes what is called the AZee *production set* for that language. The next section explains how these rules are extracted from corpus data, a methodology which we will be applying in section 4.

[3] It is worth noting that this form contains only the necessary and sufficient elements associated with the meaning "everybody agrees on *sig*".

Figure 1: Form for "pretty, beautiful" in LSF

3.2. Rule extraction methodology

Production rules only come from SL data. It is an essential point that makes it a rigorous corpus-based approach. A precise methodology exists to extract AZee production rules from data (Hadjadj et al., 2018). It consists in data searches alternating form and meaning criteria, gradually converging to strong associations ultimately leading to production rules. Form observations are done on videos with the naked eye, so it is the case in the work reported here, although additional software measurements would be possible for more accurate data, in particular for better analysis of dynamics. Meaning interpretation, though, is always assumed to be performed by a human in the process, which is also the case here.

We explain the steps of the process below, as we will be applying it later in section 4:

1. start with an arbitrary form or meaning criterion C to explore;
2. locate and list all occurrences of C in a selected SL corpus, and let N_{occ} be the number of occurrences;
3. for each occurrence of C listed, add description elements:
   - of interpretation if C is a form criterion;
   - of observed form if C is a meaning;
4. identify groups of at least two occurrences with identical description elements, and let N_{out} be the number of occurrences not included in any group;
5. if all of the following conditions are satisfied:
   - C is a meaning criterion;
   - a unique group was identified in step 4;

- N_{out} is below a threshold, e.g. 15% of N_{occ};

then the form elements defining the unique group $C.1$ can be considered invariant, and we define a new production rule associating C with the invariant form, and this iteration stops;

6. if this iteration has not stopped, for each group identified in step 4 defined by semantic or form feature f:
   - if C is a meaning that can already be expressed using known production rules justifying form f or, conversely, f is a meaning that can already be expressed using known production rules producing form C, then no new rule is to be found, nor any new search to be fired;
   - otherwise, recursively apply this methodology with a new iteration starting with criterion f—note that this new search must apply to the whole corpus again, not be restricted to the occurrences defining this group.

4. Applying the methodology

We applied the methodology presented in the previous section (section 3) on a data set of LSF, presented first. Then, after refining the notion of "interrogative" for a solid starting criterion, we detail the iterations and the resulting numbers.

4.1. Data

The LSF video data we analyzed come from *DictaSign* corpora (Belissen et al., 2020), (Hanke et al., 2010). These are semi-elicited dialogues, likely to contain interrogatives, and already translated into written French. 12 videos (total duration: 1 hour 21 minutes and 47 seconds) produced by 8 dyads of signers were examined.

4.2. Starting criterion

The first step to apply the methodology is to choose a starting criterion, of either meaning or form. In this study, being interested in interrogative utterances, we thought of the following meaning criterion: "a question is asked by the signer". But we faced the issue of determining what was indeed meant by "question" here.

First, we had to exclude what is often called "rhetorical questions" or "question-answer pairs" (Herrmann et al., 2019), which are frequent in LSF, as in other SLs. Their aim is to keep the interlocutor's attention before introducing new information, but with no real interrogative meaning (e.g.: 'DATE WHEN JANUARY' in LSF, whose sole purpose is to give an information about a date, here January, and not to question the addressee).

Secondly, although available, relying on the French translation of the corpus did not seem relevant here. Indeed, in written French, interrogatives are identified by a question mark. In LSF, the sign "interrogation mark", tracing the shape of this punctuation sign in the signing space, can be used when asking something to someone but it is far from compulsory. In fact, any request of information in SL could be translated by a French sentence with or without interrogative mark (e.g.: "What is your name?" vs. "Give me your name, please.").

We therefore clarified our starting criterion as follows. We will be calling this criterion "**IR**" (information request) henceforth:

- the signer is requesting information or confirmation from the addressee;
- the signer does not know the information, but expects the addressee to know;
- the signer expects the addressee to provide it immediately and will wait for it before proceeding.

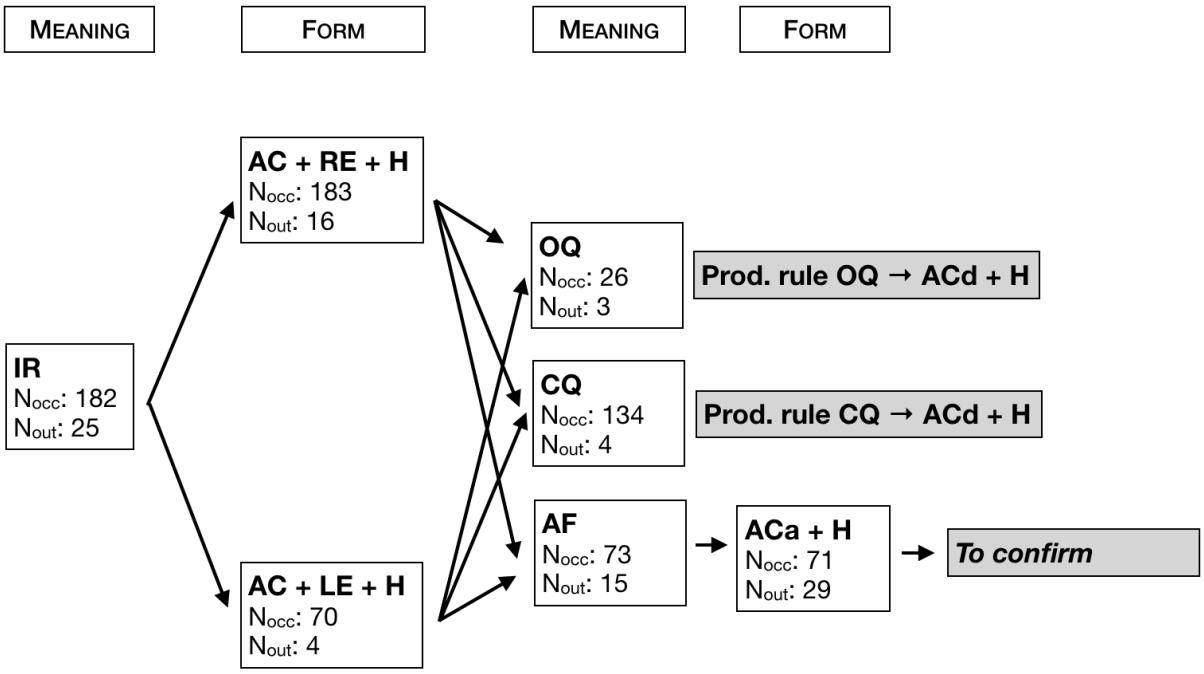
4.3. Running the iterations

We applied the methodology outlined in section 3, starting with our newly defined meaning criterion, IR. An overview of the whole process is given in Figure 2.

The first step is to identify and list all occurrences of criterion IR (meaning criterion of a request of information) in the selected corpus. We found 182 occurrences. For each occurrence of IR, we then indicate elements of form since IR is a meaning criterion. In this case we observed mixes of various form features such as the advancement of the chin (which we will note "AC" henceforth), and posture holds at the end of the production ("H"). We also chose to document eyebrow activity to test the commonly admitted proposition about questions: "RE" for raised eyebrows, "LE" when lowered. Two groups emerged depending mostly on eyebrow activity, as summarized below. $N_{out} = 25$ covers the entries that fall in neither of the groups. 15 of these entries show no advanced chin or no final hold. The other 10 do show both, but contain no eyebrow activity.

Iteration IR (meaning)

- $N_{occ} = 182$
- Groups found:
  1. **AC + RE + H** (96 entries)



IR	Information request	AC	Advanced chin
OQ	Open-ended question	RE	Raised eyebrows
CQ	Closed-ended question	LE	Lowered eyebrows
AF	Awaiting feedback	H	Final hold
		ACd	AC during the utterance
		ACa	AC after the utterance

Figure 2: Overview of iterations for IR

2. **AC + LE + H** (61 entries)

- $N_{out} = 25$

Following the methodology, we must now take each of the formed groups separately, because more than one surfaced. For each, we can either recognize a meaning–form association already accounted for by other rules of the known AZee production set, or explore further by going through the steps again, starting with the criterion defining the group. The latter case applies for both groups here, hence two new necessary iterations, one starting with search criterion "AC + RE + H" and the other "AC + LE + H".

Searching for "AC + RE + H" yields 183 occurrences. To annotate the interpreted meaning, we chose to label open vs. closed questions ("OQ" and "CQ" respectively) as it is reported relevant in the literature.[4]

[4]See footnotes 1 and 2 for a reminder of these two question types.

We also found another type of production, which fell in neither of these two cases: that of the signed flow being suspended by the signer, signifying some form of feedback is awaited (noted "AF"). This contrasts with IR since it is not an *actual* answer that is expected from the addressee. Examples are given below.

Iteration AC + RE + H (form)

- $N_{occ} = 183$
- Groups found:
  1. **OQ** (15), e.g. "What do you think about going by camper van?"
  2. **CQ** (97), e.g. "Are we going by plane?"
  3. **AF** (55), e.g. "I have two proposals for a trip..."
- $N_{out} = 16$

Since this iteration searched for a form criterion, this could not be a stopping case. We therefore

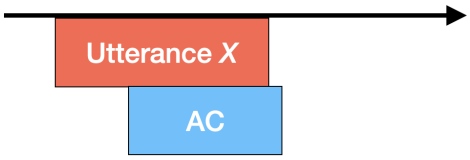


Figure 3: Form synchronization “ACd”: time flows left to right, left boundary of AC between utterance boundaries

continue with iterations until one is reached. The first search is from criterion “OQ”, in which we noticed we could be more specific yet about the timing of the AC form feature. The chin forward movement always started *during* the argument utterance, a refined criterion we note “ACd”, see Figure 3. Together with H, it allowed to capture almost the whole list of occurrences.

Iteration OQ (meaning)

- $N_{occ} = 26$
- Single group found: **ACd + H** (23)
- $N_{out} = 3$

This is a possible stopping case, because we find a single form for an identified meaning, and a number of outliers that is low enough (< 12%).

A new production rule named `Open question` can now be defined. It associates meaning OQ with form ACd + H.

Starting with “CQ” yields an outcome similar to the previous with OQ.

Iteration CQ (meaning)

- $N_{occ} = 134$
- Single group found: **ACd + H** (130)
- $N_{out} = 4$

This is also a possible stopping case. A new production rule named `Closed question` can be defined. It associates meaning CQ with form ACd + H. We notice that the two new production rules, `Open question` and `Closed question` share an identical form, which is represented on Figure 3. This will be addressed in the results section.

The following iteration, starting with the “AF” criterion, contrasts in form with the prior “OC” and “CQ”. In the case of awaited feedback, the forward chin movement tended to happen *after* the argument utterance. This refined form criterion “ACa” (fig. 4) is now different to ACd (fig. 3).

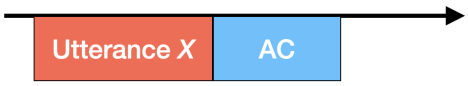


Figure 4: Form synchronization “ACa”: argument utterance and AC intervals do not overlap

Iteration AF (meaning)

- $N_{occ} = 73$
- Single group found: **ACa + H** (58)
- $N_{out} = 15$

$N_{out} = 15$ correspond to occurrences where the chin is not advanced *after* the utterance but rather *during* it. Because it is above the 15% threshold of N_{occ}, at this point this only shows that 79% of AF occurrences display a chin advancement (AC). We decided to continue the iteration with the highlighted form criterion.

Iteration ACa + H (form)

- $N_{occ} = 71$
- Single group found: **AF** (42)
- $N_{out} = 29$

Since this circles back to a previous examined meaning criterion, unsuccessfully searched, and since the present study is focused on IR, we did not pursue this iteration and chose to leave it for future work. This iteration will be done in further studies to confirm or refine with form-meaning association. At this point, results imply that: occurrences ACa are almost always occurrences of AF. However, AF occurrences can have a form that is not ACa.

We now come back to the last unaddressed iteration, namely AC + LE + H, which we processed using the same meaning features as they were equally present.

Iteration AC + LE + H (form)

- $N_{occ} = 70$
- Groups found:
  1. **OQ** (11)
  2. **CQ** (37)
  3. **AF** (18)
- $N_{out} = 4$

Each of these three groups are defined by a criterion for which a search has already been performed. So there is nothing here to explore further.

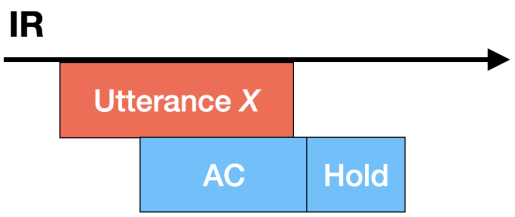


Figure 5: Form synchronization of IR

5. Results

Our results point toward two main directions. First, it allows the extraction of two new AZee production rules that we can merge into a single one, as we will explain. Secondly, it emphasizes another phenomenon that will need refinement.

5.1. A new production rule

At the end of the iterations, two new production rules have been extracted from the data.

- `Open question`
  - Meaning: Open question on utterance X
  - Form: Neck starts moving chin forward *during* utterance X (i.e. before the end of X) and final hold
- `Closed question`
  - Meaning: Close question on utterance X
  - Form: Neck starts moving chin forward *during* utterance X (i.e. before the end of X) and final hold

These two rules share an identical form. This is not a problem, however, a closer look at their respective meanings shows that they could be merged to a more generic production rule. Indeed, from a meaning point of view, "open questions" and "closed questions" are both cases of IR. This leaves us with a single rule, `Information request`, encompassing both and detailed below. It is also illustrated through the synchronization of forms on Figure 5.

- `Information request`
  - Meaning: Information request through utterance X
  - Form: Neck starts moving chin forward *during* utterance X (i.e. before the end of X) and final hold

5.2. Emergence of another phenomenon

The methodology triggered the emergence of a new meaning criterion. It is "Awaiting feedback" (AF), that is actually semantically close to IR.

Indeed, in both cases, the signer is particularly involved in the ongoing interaction. To be more precise, AF semantically differs from IR by the fact that it is not an *actual* answer that is expected by the signer, but rather a simple form of acknowledgment or back-channeling. The form associated to this meaning criterion seems to also be close to IR's since it involves AC too.

Because that is somewhat beyond the scope of this paper, we decided not to pursue iterations for AF. However, it seems that its form would differ from IR in its synchronization. Indeed, the application of our methodology shows that the unique form associated with IR is "AC *during* the utterance". Concerning AF, the current state of progress of the methodology does not allow us to establish a new production rule.

6. Discussion

This study participated in clarifying the role of eyebrows when requesting an information in LSF. This is an effect of the application of our methodology on SL data.

6.1. IR criterion and the role of eyebrows

The methodology applied with starting criterion IR led to exploring two form criteria ("Advanced chin + Raised eyebrows + 'Final hold"; "Advanced chin + Lowered eyebrows + 'Final hold") which did not end up to meaning criteria linked with traditional specific question types (i.e. open *versus* close question). Instead, it looped back to IR with a single form cue: "Advanced chin" (AC).

In this respect, these findings do not confirm some claims in the literature on interrogatives concerning an assumed difference of marking between open and closed questions. In fact, no specific shape of eyebrows linked with a particular type of question could be identified. Searching for "closed questions", we found 72% were produced with raised eyebrows, and 57% for "open questions". Comparable proportions were also found for lowered eyebrows, regardless of the type of question (42% for open questions; 27% for closed ones).

We extended the analysis to 22 minutes and 32 seconds of supplementary data from Dicta-Sign corpus and found even less relation between the type of question and the form of eyebrows (Table 1). It appears then that the distinction widely reported in the literature is not confirmed by our results.

Type of qu.	RE	LE
CQ.	140 occ. (70%)	58 occ. (29%)
OQ.	21 occ. (61%)	13 occ. (38%)

Table 1: Search for meaning criteria “CQ” and “OQ” extended to a larger data set

6.2. Advantages of the methodology

The merging of the two new production rules into a single one shows that the starting criterion, meaning criterion IR, finally made a come back in our search. This is an interesting example of the unpredictable aspect of our method using binary criteria (meaning ones *versus* form ones). It presents the advantage of letting criteria gradually emerge from SL data no matter what the researcher's intuitions are. Of course, choices are made by the researcher: see for instance the choice to focus on eyebrows in meaning groups AC + RE + H and AC + LE + H, instead of something else. Although this choice was influenced by the literature, we could have chosen to examine something else. Still, it is worth noting that the application of the methodology progressively took us away from this form criterion, revealing it to be irrelevant for meaning criterion IR. At the end, criteria can always be split, or circle back.

This work also led us to define precisely our starting criterion to search in data. If finding occurrences of a given criterion proves to be an ambiguous process, it indicates that the searching criterion is not precise enough and needs refinement. This consideration made us define the meaning criterion "Information request" (IR) instead of the less appropriate "Interrogative" or "Question".

On a larger scale, this allows us to question traditional categories of analysis in linguistics that are frequently elaborated initially for (some) spoken languages. These categories are not necessarily inaccurate but they certainly mold the way we work on SLs. Caution is therefore required when it comes to applying them to the analysis of these languages without prior critical exam. In this, the methodology used in the present work helps bringing out new categories based on the SL data, and undoubtedly more accurate ones to implement for SL generation.

7. Conclusion and prospects

Our results do not confirm the hypothesis that eyebrows play a dominant role in requests for information in LSF. We now need to continue applying our method to refine the eyebrows form. Indeed, on 182 occurrences of information requests, 93% ($n = 170$) display a movement of eyebrows (raised or lowered). This is not a problem in our approach since AZee production rules require only necessary and sufficient elements (see footnote 3).

However, different eyebrow positions might be cues of something different than the type of question. In this regard, following some recent studies, we could focus on the role of potential *biases* in closed requests, such as the signer's prior belief (Cañas Peña, 2019; Oomen and Roelofsen, 2023). These authors also introduce more fine-grained sub-categories for closed-questions (for instance, *inner* and *outer* closed-questions) that could be tested as meaning criteria in our data. Another hypothesis to explain eyebrow movements is to consider them simply as the result of a stack of other rules, for instance concerning facial expressions and the role of expression of emotions.[5]

We also intend to continue iterations for AF meaning criterion. To do so, it might be useful to extend this analysis to LSF data containing other discourse genre. Indeed, this would allow us to check if the distinction between timing of chin advancement[6] is confirmed by SL data, or if the meaning AF involves another form. Other LSF data could also allow to test close semantic categories such as “Imperative”, which also involves a request of reaction from the interlocutor. In terms of form, we should pay attention as well to the dynamics of the advancement movement in addition to its timing: for instance, a clear-cut one or a progressive one.

Finally, within the frame of AZee, the addition of a new production rule in the AZee production set increases its potential coverage of LSF. The previous set of AZee rules covered 96.1% of LSF discourse in the only corpus entirely represented with AZee, *40-brèves* corpus (Filhol and Challant, 2022), (Challant and Filhol, 2022). As this corpus does not include any questions, we are not yet in a position to quantitatively evaluate the new coverage rate on this corpus. Other studies will follow to further enrich the AZee system, thanks to the ongoing representation with AZee of the *Mocap1* corpora (Benchiheub et al., 2020). This corpus, made up mainly of image descriptions, is a specific register of LSF that represents a challenge in terms of linguistic description and modeling. It is indeed hardly modeled with sole glosses. Our initial findings underline the descriptive potential of the AZee system in this area. This is in line with an increasing coverage of AZee, for LSF for now, but the methodology could also be applied to other SLs data.

[5] For a study on this specific topic in the AZee framework, see Challant and Filhol, accepted.

[6] Starting *during* the utterance for IR rather than *after* the utterance for AF.

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