

Focus and Intensification in the Semantics of Brow Raise*

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Abstract: We argue that in American Sign Language (ASL), Brow Raise has two sorts of functions that can be distinguished by timing: it may serve well-known information-theoretic functions that can, among others, realize focus; but it may also intensify gradable constructions – a far less well-known observation. While Brow Raise *on* an expression can fulfill both functions, Brow Raise *right before* an expression preferentially has an information-theoretic function. The main findings are replicated (in an appendix) on some examples from LSF (French Sign Language). Strikingly, these two functions mirror those found for 'stress' (= emphasis) by Bergen 2016, who argued for a unified analysis of information-theoretic of intensificational effects. We sketch a unified analysis within Alternative Semantics, and discuss a further possibility within a simplified version of Bergen's own theory of 'noise-reduction' (Bergen 2016). An extension of our ASL data shows that related generalizations hold when Brow Raise is applied to a highly iconic construction (here involving a helicopter path): depending on timing, Brow Raise may serve to evoke alternatives or to intensify part of the construction.

Keywords: Brow Raise, eyebrow raising, focus, intensification, alternative semantics, noise reduction, Rational Speech Act model

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1 Introduction

1.1 Goals

Bergen 2016 argued that that what he calls 'stress' (= emphasis), characterized in English by "increased loudness, duration, and changes to the fundamental frequency", has two series of effects that are not properly unified in current analyses. One series pertains to the realization of focus, typically analyzed within Alternative Semantics (e.g. Rooth 1996): contrastive focus as in (1)a, association with an overt operator (such as *only*) as in (1)b, exhaustification (possibly by a covert operator akin to *only*, *Exh*) as in (1)c (see Fox and Spector 2018 for the last case).

- (1) Stress and focus
- a. Contrastive focus: I will introduce Mary to you and then I will introduce ANN to you.
 - b. Association with focus: I only introduced ANN to Bill at the party.
=> I didn't introduce someone other than Ann to Bill at the party
 - c. Exhaustification: Sam will invite Ann OR Bill.
=> Sam won't invite them both.

But Bergen notes that another series of semantics effects is not currently captured within Alternative Semantics. It pertains to the intensification of adjectives as in (2).

- (2) Stress and adjectival strengthening (Bergen 2016)
- a. Bob is TALL.
=> Bob is especially tall
 - b. Alice is SMART.
=> Alice is especially smart
 - c. The watch is EXPENSIVE.
=> the watch is especially expensive

Bergen argues that this is part of a broader pattern in which stress, for pragmatic reasons, serves to strengthen the truth-conditional contribution of a clause. In essence, stress is a costly signal that serves to reduce noise, i.e. the risk that the message will be corrupted during transmission. But due to its cost, stress also signals that the relevant part of the signal carries particular importance, hence a strengthening of its truth conditions.

While the data discussed by Bergen seem clear enough, the claims are controversial: are the phenomena in (2) genuinely related to those in (1)? And if so, are they a challenge to Alternative Semantics? The controversy only deepened when Wagner 2020 noted that in spoken language the unity of focus and intensification is at best partial: focus doesn't just require accenting the focused element but also deaccenting the unfocused (given) parts, whereas no such requirement holds for intensification. This might suggest that in the end the apparent connection between (1) and (2) is accidental.

Our original goal was to determine whether the cluster of phenomena that Bergen takes to be unified by stress form a natural class relative to other properties in sign language. Specifically, we asked whether eyebrow raising (henceforth Brow Raise) in American Sign Language (ASL), which is known to have among others the functions in (1) (e.g. Schlenker et al. 2016), also has the functions in (2). This was part of a multi-year collaboration between a semanticist and a consultant who is a native signer of ASL, with elicitation methods that have been refined over the years, as discussed below. Due to the complexity of the data, we only focused on ASL versions of (1)a,b and (2). We first obtained a positive result: in our data, Brow Raise can clearly intensify adjectives. But something unexpected happened in the process: the native signer among the authors noticed that the information-theoretic functions in (1)a,b can usually be distinguished by timing from the intensification function in (2)a; while Brow Raise before an expression can serve to mark focus, it has much greater difficulty marking intensification.

Correspondingly, this article has three main goals. First, we establish that Brow Raise in ASL can have an intensification function in addition to its information-theoretic functions; this is to our knowledge a new finding, one that provides a new argument for Bergen's claim that focus and intensification form a natural class. Second, we show that in most cases the two functions can be distinguished by timing: Brow Raise on an expression can have either function, but Brow Raise before an expression usually only has the information-theoretic function (LSF examples that replicate this generalization are discussed in an appendix). The facts are subtle, however, as an intensification function can to some extent be regained in preposed position if Brow Raise is heightened (= involves higher eyebrow raising).

We then discuss the consequences of our findings for theories of focus and intensification. We first sketch an account within Alternative Semantics: we develop a new account of intensification by focus, but we note that some assumptions are currently *ad hoc*, and fail to account for the fact that heightened preposed Brow Raise can have an intensificational effect. We then develop an analysis that can more easily accommodate the latter fact within a simplified version of Bergen's noise-reduction analysis. While it needs auxiliary assumptions to derive the data, these might be rather plausible.

1.2 *Brow Raise*

But first, what is the semantics of Brow Raise? It is uncontroversial that it can have an information-theoretic role, including to mark focus. But the diversity of its functions has made a unified analysis elusive. Quer 2016 offers a helpful typology of extant approaches (however it must be borne in mind that different authors base their conclusion on different sign languages).

(i) The *prosodic view* takes sign language Brow Raise to correspond to certain prosodic properties in spoken language. In Dachkovsky's analysis "Brow Raise corresponds to the meaning of the High boundary tone in many spoken languages" (Sandler 2011, following Dachkovsky 2005 and Dachkovsky and Sandler 2009). Functionally, Brow Raise indicates that "the phonological or intonational phrase marked by it is to be followed by another constituent, produced either by the same interlocutor or, in the case of yes/no questions, by another" (Sandler 2011). While the authors base their analysis on data from Israeli Sign Language, Sandler 2011 takes it to extend to the ASL data discussed by Wilbur and Patschke 1999.

(ii) By contrast, other researchers take Brow Raise to express certain *morphosyntactic or semantic properties*.

(a) For Neidle et al. 2002, ASL Brow Raise marks the c-command domain of a morphosyntactic feature (Neidle et al. 2002).

(b) For Wilbur and Patschke 1999, it marks A-bar (=non-argumental) positions associated with [-wh] operators in the syntax.

(c) More recently, Wilbur 2011 takes ASL Brow Raise to mark the restriction of dyadic operators. For her, "dyadic operators apply to various constructions: conditionals, interrogatives, focus structures, relatives, and generics (...). In ASL, the part that restricts subsequent interpretation is marked with br [= Brow Raise]: a conditional clause provides the conditions under which the next clause is likely to hold; without 'br', the two clauses are read as conjoined."²

Wilbur 2011 takes the stereotypical case of focus to involve association with a particle such as *only*, as in Rooth's analysis (e.g. Rooth 1996). Schlenker et al. 2016 discuss ASL and LSF instances of Brow Raise marking exhaustive focus (which can be analyzed in terms of a covert *only*), but also contrastive focus. Wilbur's analysis might have to be slightly extended to capture the latter cases.³

² Quer 2016 develops a different theory of Brow Raise for Catalan Sign Language (LSC); for him, Brow Raise "is a portmanteau marker of syntactic integration of the dependent clause into the matrix, potentially layered with other nonmanuals".

³ In Rooth's account (e.g. 1996), cases of contrastive focus as in (i) do involve a dyadic operator, the ~ operator. For instance, in the underlined constituent, ~ introduces a presuppositional requirement that the

On various theories, including Dachkovsky and Sandler's prosodic view and Wilbur's dyadic restriction view, it is unsurprising that Brow Raise should have focus-related uses. This function might be cognitively central since it is also found as a co-speech gesture marking focus in spoken language (Dohen and Loevenbruck 2009). On the other hand, the intensification function of Brow Raise has to our knowledge rarely been discussed, and is a central topic of our investigations.

1.3 Structure

The rest of this piece is organized as follows. We summarize the debate about Bergen's proposal in Section 2. Turning to sign language, we introduce our elicitation methods and transcription conventions in Section 3. In Section 4, we show that contrastive focus and association with focus can be marked by Brow Raise on or right before an expression. In Section 5, we show that Brow Raise can also intensify adjectives, but that this requires that it appear on an expression, unless Brow Raise is heightened. An analysis within Alternative Semantics is sketched in Section 6. In Section 7, we present a simplified version of Bergen's noise-reduction theory: it can immediately account for the dual (focus-related and intensificational) function of Brow Raise, and can also account for the distinction between Brow Raise on vs. before an expression, but at the cost of additional (if relatively plausible) assumptions. We present an extension of our main generalizations to a highly iconic construction involving a helicopter path in Section 8, before concluding in Section 9. (Appendix I includes technical notes, Appendix II outlines a preliminary replication to LSF, and Appendix III discusses a highly simplified (but still quantitative) version of a noise-based analysis.)

2 The debate about focus and intensification: Bergen's proposal and Wagner's objection

2.1 Bergen's proposal

In each of the examples in (2) (e.g. *Alice is SMART*), stress intensifies the adjective and thus strengthens the truth conditions of the clause it appears in. For Bergen (2016), this is part of a broader pattern: even outside of the adjectival domain, stress alone can strengthen truth conditions. A case in point is that of quantifiers, as in (3). Their implicit domain restriction is usually determined by contextual consideration, but stress can modulate the domain restriction, in different directions for different quantifiers: for *every* and *no*, the effect is to enlarge the domain; for *some*, it is to narrow it.

- (3) Stress and quantifier strengthening (Bergen 2016)
- a. EVERY girl came to the party.
=> enlargement of the implicit restriction: every girl within a larger than expected domain came to the party
 - b. NOBODY brought presents.
=> enlargement of the implicit restriction: nobody within a larger than expected domain brought presents
 - c. SOME of the students passed the test.
=> narrowing of the implicit restriction: some students within a very small domain passed the test

value of the variable P_2 , coindexed with *Canadian farmer*, should be part of the focus value of *American_F farmer* (and this condition is satisfied because a Canadian farmer is an X farmer for some alternative X to *American*).

- (i) An $[[[American]_F farmer]_1 \sim P_2]$ was talking to a $[[[Canadian]_F farmer]_2 \sim P_1]$.

What is not clear to us, however, is in what sense contrastive focus appears here in the *restrictor* of this dyadic operator.

Why should stress have such diverse effects on implicit quantifier domain restrictions? Bergen argues that in each case, stress strengthens the truth conditions. To do so for a clause with a universal positive or negative quantifier (e.g. *every girl, nobody*), one must enlarge the domain: *nobody among Ann, Bill, Carol and Don brought present* is a stronger statement than *nobody among Ann, Bill and Don brought present*. By contrast, to strengthen the truth conditions of an existential quantifier (e.g. *some of the students*), one must narrow the quantifier domain: *some of the students among Ann, Bill and Carol passed the test* is a stronger statement than *some of the students among Ann, Bill, Carol and Don passed the test*. In fact, the domain may arguably be restricted to a singleton individual (as in Schwarzschild 2002), hence a near-referential reading.⁴

Bergen 2016 develops a new analysis within the Rational Speech Act model of pragmatics (e.g. Goodman and Frank 2016, Franke and Jäger 2016, and Bergen et al. 2016). His leading idea is that, as in any signal transmission, there is a slight risk of corruption (henceforth 'noise'⁵), and that the function of stress is to reduce it. He then shows that, in simple cases at least, the phenomena in (1), (2) and (3) can be explained by positing that the speaker uses stress to reduce, at some cost, the risk of corruption of a certain part of a message. Doing so signals that that part carries a particularly important function, and this inference can be exploited for communicative purposes by way of recursive reasoning (the addressee reasons on the speaker's intentions, the speaker takes into account the addressee's reasoning, etc); the strengthening effect follows.

2.2 Wagner's objection

Following Wagner 2020, a reviewer states the following objection.⁶ There are multiple ways to reduce noise, but in English they are insufficient to mark focus unless they are accompanied by a shift in prominence. This shift involves both reducing the non-focused (= given) expression (a reduction marked below with angle brackets <...>) and boosting the focused element by increasing its duration, pitch and intensity (this is marked by capitalization). Consider (4):

- (4) A: Who wants coffee?
 B1: EDE <wants coffee>.
 B2: EEEEEEEEEEEDE <wants coffee>.
 B3: EDE EDE EDE EDE EDE <wants coffee>.
 B4: #EEEEEEEEEEDE wants COFFEE.
 B5: #EDE EDE EDE EDE EDE want COFFEE.

As the reviewer notes, "the question in the context requires *wants coffee* to be metrically less prominent than *Ede*, as in B1-B3's responses. (...) We can add to the prominence of *Ede* by lengthening it absurdly (B2), or repeating it over and over again (B3), but crucially all of these strategies are not sufficient to satisfy the constraint that focus imposes: we also have to reduce 'wants coffee', since B4 and B5 sound incoherent". Things are very different with intensification: lengthening and repetition suffice to mark it in (5)B1-B2, while deaccenting the NP is prohibited (because it is semantically in focus) in (5)B3.

- (5) A: What did you end up doing for Rowan's birthday?
 B1: I had so much trouble thinking of a present. In the end I just cooked a DELIIIIIIICIOUS DINNER for her.

⁴ Bergen 2016 cite the following:

(i) *Context*: Bob is addressing his students before class. He looks at a particular student.
 Bob: SOME of you didn't hand me your homework yesterday.
 [Understood meaning: The student that Bob is looking at did not hand in his homework yesterday.]

⁵ There can be 'noise' in any signal, including in writing or in signs.

⁶ The reviewer elaborates the objection far more deeply than we could have on the basis of Wagner 2020, and thus we cite the reviewer's version.

B2: I had so much trouble thinking of a present. In the end I just cooked a DELICIOUS DELICIOUS DINNER for her.

B3: # I had so much trouble thinking of a present. In the end I just cooked a DELICIOUS <dinner for her

To summarize, the problem is twofold: (i) prominence must be accompanied by deaccenting in the case of focus but not of intensification; (ii) various means of noise reduction (such as repetition) can be used to effect intensification, but not focus.

2.3 Outlook

Taking into account Wagner's objection, we are led to three main theoretical possibilities, with different expectations for the signed modality, and different challenges.

Option 1: No unification: One possible conclusion is that the unification of focus and intensification is just wrong-headed: it might be an accident that similar mechanisms (involving pitch, duration and loudness) are sometimes found in both domains. It might even be that Bergen's noise-reduction-based analysis is correct for intensification, but not for focus. On this view, we don't expect that in signs the same means should be employed to mark focus and intensification.

Since by Wagner's objection unification between focus and intensification cannot be complete, we are left with two 'partial unification' views: one within Alternative Semantics, and one within Bergen's own framework.

Option 2: Partial unification within Alternative Semantics: Focus and intensification could be partly unified along the lines of Alternative Semantics: focus involves both reduction and prominence, as in Wagner's objection, while intensification just involves prominence. On this view, we could expect sign language to employ in part the same mechanisms to mark focus and intensification. For instance, on the prosodic view, Brow Raise might be expected to be the counterpart of intonational patterns in speech that can mark both focus and intensification. On a theoretical level, the main challenge is to explain how Alternative Semantics can derive intensification (in either modality).

Option 3: Partial Unification within Bergen's noise-based analysis: Alternatively, one may effect a partial unification within Bergen's noise-based framework. What focus and intensification have in common is already clear from Bergen's framework. In sign, mechanisms that can reduce noise (such as increased duration and greater sign amplitude) can be expected to realize both focus and intensification. Brow Raise could play this very role, for instance because it brings attention to a particularly important part of the message. Still, by Wagner's objection, the challenge would still be to explain how reduction is to be accounted for in the case of focus (but not intensification).

This might not be unsurmountable. Adding emphasis has the benefit of reducing noise but the drawback of being more costly, and it should thus be used for the most important parts of a message. By symmetry, deaccenting might have the drawback of increasing noise, but the benefit of decreasing cost, and it should thus be used for the less important parts of a message, notably ones that are given. Developing this view is a separate enterprise, but doing so might help address Wagner's objection within Bergen's framework.

In the rest of this paper, we will discuss three main findings from ASL (with an initial replication in some LSF examples in Appendix II):

1. One and the same formal device, Brow Raise, has focus- and intensification-related uses in ASL, which suggests that Bergen's unification was not wrong-headed, against Option 1. This leaves Options 2 and 3.
2. But an unexpected finding in view of the current debate is that focus and intensification are distinguished along new lines by the sign language data: focus can be marked by Brow Raise on or before an expression; intensification usually requires Brow Raise *on* an expression. In

Wagner's data, focus is more demanding than intensification, since the latter allows for diverse means of emphasis (including repetition), and does not involve deaccenting. In our sign language data, intensification is more demanding, since it requires Brow Raise on rather than before the target expression.

3. On a theoretical level, we will sketch ways to develop Options 2 and 3. Within Alternative Semantics, we will posit an operator ('noteworthiness') which is trivialized in standard focus-related cases but strengthens the truth conditions in intensificational cases. Within (a simplified version of) Bergen's theory, we will show that some (arguably plausible) assumptions about the relative cost and noise-reducing behavior of different versions of Brow Raise can account for the data.

3 Methods and transcription conventions

3.1 Elicitation methods and limitations

Our ASL data were elicited from Lamberton, who is a native Deaf signer of Deaf, signing parents (theoretical issues were discussed with him after elicitation was complete). We obtained acceptability judgments using the 'playback method', with repeated quantitative acceptability judgments (1-7, with 7 = best) and repeated inferential judgments (on separate days) on videos involving minimal pairs (for earlier uses of the playback method, see for instance Schlenker et al. 2013, to appear; Kuhn 2016). Acceptability judgments pertained to entire sentences, but in many cases separate acceptability judgments were also collected on the realization of a word of interest. The goal was to get more fine-grained judgments: a sentence as a whole may seem relatively acceptable even though the non-manual on a word is suboptimal. In such cases, asking for the acceptability *of the target word* yields more fine-grained contrasts. We indicate clearly at the beginning of each example whether acceptability judgments pertain to the entire sentence or to a word of interest (in the latter case, acceptability judgments for the entire sentence can be found in the Supplementary Materials).

Our method was a more transparent and scripted version of standard elicitation techniques used in linguistics. For accuracy, and in line with recent work that uses similar methods (e.g. Schlenker et al. 2013, and many more recent pieces), acceptability judgments appear as numerical superscripts at the beginning of sentences, thus replacing the symbols *, ??, or ? traditionally used in syntax. This shouldn't suggest that results are experimental in nature: they are not.

When fine-grained inferential contrasts were needed in ASL, we asked for judgments of inferential strength, also on a 7-point scale (with 7 = strongest inference). Quantitatively assessing inferential strength is by now standard in experimental semantics, for reasons discussed for instance in Cremers and Chemla 2017; as they write, graded inferential judgments "may help detect otherwise hidden effects". Quantitative inferential judgments have also proven useful in work on sign language semantics (e.g. Schlenker 2021).

In all cases, only averages of the quantitative scores obtained are provided in the text, with raw scores in parentheses when there was more than a 2-point difference among them. Raw data, including all scores and written inferential judgments (each of which was also redundantly signed on a video), can be found in the Supplementary Materials.

The playback method made it possible to ask the consultants (in ASL and LSF alike) to produce minimal pairs differing primarily by Brow Raise placement. For this reason, the *production* part was artificial, just as it would be for the creation of experimental stimuli. But the subsequent (and repeated) *judgment* task (by the same signer) made for minimal comparisons between appropriate and deviant sentences depending on the placement of Brow Raise.

Importantly, creating truly minimal pairs with non-manuals is extremely challenging; although our paradigms were minimal with respect to the presence and timing of Brow Raise, they were not as minimal as we initially hoped concerning other non-manuals. As things stand, this is just the best we could do, and more sophisticated methods will probably have to be used to produce even more minimal pairs in the future.

3.2 Transcription conventions

ASL data were transcribed by Lamberton himself. In Appendix II, LSF data were initially transcribed by Schlenker for the presence and timing of Brow Raise and Brow Lowering. But for uniformity, Lamberton used the same fine-grained transcription as in ASL for non-manuals and sign modulations.⁷ While Lamberton has considerable experience with scientific transcriptions, it should be kept in mind that in the case of manual modulations and non-manuals this is often a particularly difficult task, with judgment calls involved at several junctures.

As is standard, sign language glosses are capitalized. Loci are alphabetically ordered from the dominant to the non-dominant side. *IX-i* represents a pointing sign toward locus *i* (usually to realize a pronoun, with *IX-1* and *IX-2* referring to the speaker and the addressee respectively). Loci affixed to verbs represent agreement markers; a word signed in locus *i* is glossed as *WORD_i*.

For reader-friendliness, we follow Schlenker et al. 2016 in using a revised transcription system (the *SLASH-notation*⁸) in which sign modulations are indicated by modifying the glosses themselves, while non-manuals appear above the capitalized glosses, with a line indicating their duration, and iconic symbols whenever possible – in the order: 1. body changes 2. head changes 3. facial expressions, e.g. /ʃ[^]. We add to the conventions of Schlenker et al. 2016 a distinction between normal Brow Raise (= [^]) and heightened Brow Raise (= ^Λ). (Longer hold times and speed accelerations were not encoded in this piece because no striking contrasts were found.)

(6) a. Non-manuals: / = forward lean; \ = backward lean; ‡ = raised shoulders } = head nod;

[^] = normal raised eyebrows; ^Λ = heighed raised eyebrows; [~] = lowered eyebrows

b. Sign modulations: **WORDS** = greater amplitude; WORDS = longer hold time;

+WORD or +[WORDS]+ = speed acceleration

In addition, we need a distinction between the case in which Brow Raise appears on a word (the standard case), as in (7)a, or right before a word (cases of interested investigated here), as in (7)b: we distinguish these cases by symbols ([^] vs. [^]_) and by way of alignment, as shown in (7).

(7) a. Brow raise on a word	b. Brow raise before a word
[^] <hr style="width: 100%; border: 0.5px solid black;"/> WORD	[^] _ <hr style="width: 100%; border: 0.5px solid black;"/> WORD

Proposed Brow Raise was always transcribed before other non-manuals, with no claim about the relative timing of Brow Raise and other non-manuals: we only sought to assess whether it was realized on or right before the manual component of the relevant word.

Non-manuals were only included in the transcriptions of the emphasized words or in the corresponding controls. Sentences included in the same numbered example were signed and evaluated as part of the same video, and they thus form minimal pairs.

To illustrate, the partial example in (8), extracted from (10) below, involves one word, namely *B_{ILL_b}*, whose realization changed from example to example (the subscripted locus *b* reflects the fact that *B_{ILL}* was signed on the left).

(8) Acceptability of the contrastively focused word, *B_{ILL_b}*

...
a. ^{1,3} *B_{ILL_b}*
 /ʃ^Λ_____

⁷ This measure has the advantage of uniformity (these fine-grained properties were transcribed with the same criteria), but it comes with obvious limitations as well: Lamberton is an ASL and International Sign signer, not an LSF signer. The reader can disregard the fine-grained details found in our LSF transcriptions if they so desire.

⁸ For more on the SLASH-notation, see:

https://sites.google.com/site/linguaeparis/sign_language_slash_notation

b. ⁷ **B_{ILL_b}**

...

(ASL, [35.0684](#); 3 judgments)

The part copied in (8)a indicates that when *B_{ILL_b}* was realized without emphasis, this word was judged to be degraded, with an average acceptability of 1.3 over 3 iterations of the judgment (on different days). The part copied in (8)b transcribes *B_{ILL_b}* realized with greater sign amplitude, hence the boldfacing. The sign was accompanied with a forward lean (glossed as /), a head nod (glossed as }), and a heightened Brow Raise (glossed as ^; it would have been ^ for a normal Brow Raise). Acceptability of the word realized in this way was at ceiling, with an average score of 7. The notation (ASL, [35.0684](#); 3 judgments) at the end of the example provides the number of judgments obtained, and the reference of the video in which the target sentences were recorded.

The Supplementary Materials can be consulted to obtain full written judgments on that videos (the judgments were also signed, redundantly, on separate videos). To provide maximal access to the data while respecting the consultant's privacy, semi-anonymized ASL videos have systematically been made available below.

4 Contrastive focus and association with focus in ASL

4.1 Movement vs. prosody in ASL focus marking

How is focus marked in ASL? Wilbur 1999 establishes that "the primary indicator of stress marking is the significant increase in peak velocity of prominent signs", and that as in English "a single prominence is assigned to the right-most lexical item in the phrase", but that unlike in English prominence cannot be moved, with the result that focus is preferably realized by movement (as in other languages that Vallduví 1991 calls [-plastic], such as Catalan). Still, there are cases in which the focused elements remain in situ (some appear in Wilbur and Patschke 1998 and Lillo-Martin and Quadros 2008).

Schlenker et al. 2016 investigated ASL and LSF examples in which movement is inapplicable, and showed that prominence and non-manuals alone can realize two types of focus: contrastive, and exhaustive (yielding readings akin to those obtained with a covert *only*). As they concluded, "increased amplitude, speed acceleration, longer hold times, and raised eyebrows were found in ASL and LSF alike (very systematically for raised eyebrows and forward leans/head nods)".⁹ But since they were interested in the clusters of properties that can realize focus, they did not tease apart the specific role of Brow Raise. This is what we attempt to do in the rest of this piece, by investigating paradigms that only differ, to the extent possible, with respect to Brow Raise, both on and before a word (producing truly minimal pairs is very difficult, hence our rider 'to the extent possible').

4.2 Contrastive focus

We start by modifying two paradigms from Schlenker et al. 2016 in order to assess whether contrastive focus can be marked by way of Brow Raise not just *on* a word, but also *before* a word. We asked for acceptability judgments both for the target sentence as a whole, and for the target word (whose realization changes from sentence to sentence). The latter judgments were more informative, which is unsurprising in view of the relative subtlety of prosodic/non-manual cues, as they could easily get drowned by other properties of the sentence. We thus focus on acceptability of the target word.

⁹ In addition, "forward leans were found in our ASL but not in our LSF data; head nods were found in LSF (and might or might not have been part of 'forward leans' in ASL); and a couple of instances of shoulder raising were found in LSF but not in ASL."

4.2.1 Example (9), modified from Schlenker et al. 2016, contrasts words A_{NN_a} AND B_{ILL_b} in the first clause with the words A_{NN_a} OR B_{ILL_b} in the second.

(9) (Acceptability of OR)¹⁰

Context: The speaker is an ASL instructor teaching students to sign 3-word sequences.

IX-2 WILL SIGN ' A_{NN_a} AND B_{ILL_b} ', FINISH ' A_{NN_a} _____ B_{ILL_b} '

a. ^{3,7} OR (2, 4, 5)

$\downarrow\uparrow\Delta$

b. ⁶ OR

\downarrow

c. ⁶ OR

Δ

d. ⁶ OR

Δ -_____

e. ^{6,7} OR

Δ - $\downarrow\uparrow$

f. ^{6,3} OR

'You will sign ' A_{NN} AND B_{ILL} ', then ' A_{NN} OR B_{ILL} '. (ASL, [35.0694](#); 3 judgments)

Anonymized video: <https://youtu.be/S2XMpFIClbe>

Due to the contrast with *AND*, *OR* is degraded when it appears without emphasis, as in (9)a. With diverse means of emphasis including Brow Raise, as in (9)b, the word is acceptable. It continues to be acceptable when just greater amplitude and forward lean are used, as in (9)c. Crucially, Brow Raise alone can be used as well, and this is the case whether it appears on the word, as in (9)d, or right before, as in (9)e (unsurprisingly, preposed Brow Raise combined with further means of emphasis is also acceptable, as seen in (9)f). It should be noted that the Brow Raise found in (9)d,e was transcribed as 'heightened', although our intention was to have even more minimal pairs with the same level of Brow Raise across sentences.

The paradigm in (7) is slightly less telling because the preposed version of Brow Raise co-occurred with greater manual amplitude. With this limitation, the findings are compatible with those in (9). The paradigm uses five letters of the manual alphabet to stand for five proper names (a standard device in ASL): *A* for Ann, *B* for Bill, etc. The name for B_{ILL} contrasted with C_{HARLES} .

(10) (Acceptability of B_{ILL_b})

Context: The speaker is trying to teach groups of students to work together.

TODAY IX-1 SEVERAL MEETING-rep FIRST MEETING A_{NN_a} C_{HARLES_b} E_{DITH_c} D_{ENIS_d} ,

FINISH A_{NN_a} _____ E_{DITH_c} D_{ENIS_d}

a. ^{1,3} B_{ILL_b}

$\downarrow\uparrow\Delta$

b. ⁷ B_{ILL_b}

$\downarrow\uparrow$

c. ^{4,7} B_{ILL_b}

$\downarrow\uparrow\Delta$

d. ^{6,3} B_{ILL_b}

Δ -_____

e. ⁶ B_{ILL_b}

Δ - $\downarrow\uparrow$

f. ^{6,3} B_{ILL_b}

'Today I have several meetings. My first meeting is with Ann, Charles, Edith and Denis, then [I met] with Ann, Bill, Edith and Denis.'

(ASL, [35.0684](#); 3 judgments)

Anonymized video: <https://youtu.be/gLrLLI-LsFDQ>

¹⁰ There was a numbering error in the raw data, with c, d, e instead of d, e, f appearing in the sentences; this does not seem to have caused confusions since the consultant used all appropriate columns.

In (10)a, not marking contrastive focus in a clearly contrastive environment is dispreferred. A cluster of focus-marking strategies including Brow Raise is used in (10)b, with ceiling acceptability. (10)c uses the same marking strategies but without Brow Raise, with less acceptable results. (10)d uses Brow Raise on *BILL*, with a head nod (which wasn't intended). (10)e has Brow Raise right before *BILL*, and as mentioned an (unintended) increase in manual amplitude. The result is acceptable, and likely due to Brow Raise rather than to greater amplitude, since the latter gave rise to decreased acceptability in (10)c. (10)f has a cluster of focus-marking properties on *BILL*, and also preposed Brow Raise, again with high acceptability.

The conclusion as this point is that contrastive focus preferentially involves Brow Raise (and can involve further means of emphasis as well), but that Brow Raise can be realized on or just before the focused word, with little difference. Future work should seek to produce even more minimal pairs to further buttress these conclusions.

4.3 Association with *ONLY*

Some particles, such as *only* in English, associate with focus and yield different truth conditions depending on which item is focused, as in (11). This makes it possible to test the effect of focus marking by way of inferential rather than acceptability judgments.¹¹

- (11) a. I only introduced ANN to Bill at the party.
 => I didn't introduce other people than Ann to Bill at the party
 b. I only introduced Ann to BILL at the party
 => I didn't introduce Ann to other people than Bill at the party

The paradigm in (12) tests the inferential effect of Brow Raise appearing on or right before the last word of the sentence, the pronoun *IX-b*. The advantage of investigating the last word is to avoid ambiguities that arise when Brow Raise precedes a multi-word sequence: it may become unclear whether Brow Raise modifies just the following word or a longer sequence. (12)a is a control with no emphasis, while (12)b involves multiple means of emphasis: greater sign amplitude, a forward lean, a head nod, and Brow Raise. All other examples involve only Brow Raise, on or before the pronoun, and in two versions: normal Brow Raise, heightened Brow Raise (with higher eyebrows).¹² We intended the production of (12)c to involve normal Brow Raise and (12)d to involve heightened Brow Raise, but both turned out to be transcribed as heightened. Preposed Brow Raise was of normal size in (12)e and heightened in (12)f, and (unintentionally) accompanied with a head nod in (12)d.

- (12) (Acceptability of the last word of the sentence.)
 YESTERDAY IX-1 1-MEET JOHN_a MARY_b. IX-1 ONLY PERMIT IX-a a-HELP-b ____ .
 a. ⁷ IX-b
 /}Λ
 b. ⁷ **IX-b**
 Δ
 c. ^{6,7} IX-b
 Δ

¹¹ We include sentence-final modifiers in (11) because otherwise the last word of the sentence would also be the last word of the VP, and emphasis on it could potentially mark focus on the entire VP (this is due to rules of focus projection: for Selkirk 1995, a focused argument can F-mark its verb, which in turn can F-mark the entire VP). The judgments we report suggest that this potential ambiguity did not extend to our ASL data.

¹² We only tested Brow Raise and not Brow Lowering in our ASL data. Brow Lowering should be investigated in this context in the future, as the consultant once noted in relation to (12)b that he "would probably use lowered eyebrows rather than raised eyebrows for this kind of emphasis."([JL 19.10.03]).

d. ^{6.7} IX-b¹³

^_} _____

e. ⁶ IX-b

^_ _____

f. ⁶ IX-b strong

'Yesterday John and Mary. I only allow him to help her / HER.' (ASL, [35, 1518](#); 3 judgments)

Anonymized video: <https://youtu.be/OT8eOJU0KWg>

(13) Inferential question: What does the signer DISALLOW?

(i) that someone other than John help Mary

(ii) that John help someone other than Mary

(iii) something else (say what)?

(Indicate with which strength you derive the relevant inferences: 1 = no inference; 7 = strongest inference)

The signer DISALLOWS	a.	b.	c.	d.	e.	f.
(i) that someone other than John help Mary	5.7 (4, 6, 7)	3	4.3	3.3	4 (2, 5, 5)	3.7 (2, 5, 4)
(ii) that John help someone other than Mary	6.3	7	6.7	6.7	6.7	6.3
(iii) something else	6	2	3.7	2.3	3.7	3

Inferential effects were assessed by way of the difference between the target sentences, with emphasis on the last word, and (12)a, where no word was emphasized. The effect of focus on the last word was expected to only disallow one alternative, namely that John help someone other than Mary (since the pronoun referring to Mary was emphasized). This was indeed found in (12)b-f.¹⁴ In (12)a, the absence of emphasis made it underspecified what *ONLY* associated with. In view of the consultant's responses, it seemed to associate with the entire proposition, thus disallowing all conceivable alternative propositions, namely (i) that someone other than John help Mary, (ii) that John help someone other than Mary, (iii) something else, which the consultant took to be that Mary help John.

Importantly, in all cases, inferential effects are broadly indicative of association of the final pronoun with *ONLY*: Brow Raise right before the final word seems to work like Brow Raise on the final word, though possibly less clearly. There was no clear difference between normal and heightened Brow Raise. A limitation of this paradigm (and of the next one) is that we can't exclude the possibility that the head nod was crucial to mark focus in the case of preposed Brow Raise in (12)e.

A related pattern can be seen in (14). As before, the target inference is that the signer disallows that John helps someone other than Mary.¹⁵ All the examples with emphasis, in (14)b-f, give rise to the inference that the signer disallows John from helping someone other than Mary, and doesn't disallow anything else (among the options offered). Without emphasis, as in (14)a, *ONLY* seems to associate with the entire embedded proposition, hence all conceivable propositions are disallowed. Here too, we can't exclude the possibility that a head nod plays a role in focus marking in (14)e,f.¹⁶

¹³ Both c. and d. have been transcribed as heightened Brow Raise, but in addition wide open eyes appear in d., which make the Brow Raise appear even stronger.

¹⁴ However in (12)e,f, where Brow Raise occurred before a word, there was some variation across judgment tasks in the endorsement of the inference that the signer disallows someone other than John help Mary; we expected it not to be endorsed, but the effect was weaker than we would have thought.

¹⁵ The consultant noted that the "function of *ONLY* not entirely clear in these sentences. Is it "merely" - The only thing the signer is requesting is this. Or is it limiting - The signer wants this and only this to happen. For these sentences, I'll assume the latter." ([JL 19.09.29])

¹⁶ As the consultant noted, a pragmatic step is needed in all these examples: "We understand what signer wants, but for other than what is mentioned, are they neutral or unwanted/disallowed? I tend toward unmentioned = disallowed." ([JL 19.10.05], by email).

- (14) (Acceptability of the last word of the sentence)
 YESTERDAY IX-1 1-MEET JOHN_a MARY_b. IX-1 ONLY WANT IX-a a-HELP-b ____.
- a.⁷ IX-b
 $\overline{\wedge}\Delta$
- b.⁷ **IX-b**
 $\overline{\wedge}$
- c.^{6.3} IX-b normal
 $\overline{\wedge}$
- d.^{5.3} IX-b strong
 $\overline{\wedge}_}$
- e.⁶ IX-b normal
 $\overline{\wedge}_}$
- f.^{5.7} IX-b strong
 'Yesterday I met John and Mary. I only want him to help her / HER.' (ASL, [35, 1476](#); 3 judgments)
 Anonymized video: <https://youtu.be/Ar-7mmkWLPY>

(15) Inferential question: same as in (13)

The signer DISALLOWS	a.	b.	c.	d.	e.	f.
(i) that someone other than John help Mary	5	2.7	3	2.7	2.7	2.7
(ii) that John help someone other than Mary	5	6.3	5.3	6.3	5.3	5.7
(iii) something else	4 (5, 1, 6)	1.7	1.7	1.7	1.7	1.7

Importantly, there seems to be little difference between Brow Raise on or before an expression: all signal, to some extent at least, focus on the relevant word.

In sum, in our data, Brow Raise can mark focus on an expression, both in the case of contrastive focus and association with *ONLY*. There seems to be little difference between Brow Raise on a word and Brow Raise right before it. But a limitation is due to the fact that our paradigms are not entirely minimal due to the presence of head nods that may mark focus in tandem with preposed Brow Raise, in particular. As we will now see, when it comes to intensification, timing seems to matter more.

5 Intensification by Brow Raise in ASL: the role of timing

5.1 Diversity of intensification strategies

As we will now see, Brow Raise also has intensification functions. But it should be kept in mind that there are diverse modulations that can help realize intensification in sign language.¹⁷ Summarizing earlier literature, Aonuki 2019 mentions that intensification in ASL has been described as involving "longer duration of an initial hold and presence of a (longer) final hold, enlargement or addition of a movement path, and nonmanual components (Klima & Bellugi, 1979; Padden, 1988; Brentari, 1998; Sandler & Lillo-Martin, 2006; Wilbur, Malaia, & Shay, 2012)". Concerning non-manuals, Wilbur et al. 2012 tangentially discuss "frown on face" and "head tilt away from neutral", but not Brow Raise.

In a production study with a non-native fluent signer of ASL, Aonuki (to appear) finds "statistical support for longer duration of initial and final holds as well as enlargement of path movement under intensification". Concerning non-manuals, she found that "intensified signs show increased involvement of head or torso movements aligned with the manual movement in rhythm or direction", but she did not investigate other non-manuals.

Displaying an intensification function of Brow Raise is thus of interest in its own right, since it has not been well documented in the earlier literature. As mentioned in the introduction, it is also an important theoretical question to determine (i) whether it should be unified with focus-

¹⁷ In addition, one may in some cases use iconic scales to represent degree modifications; see Aristodemo and Geraci 2018.

related uses, and if so (ii) how. In addition, we will now see that the relevant data raise a new puzzle because in this case the two realizations of Brow Raise mostly part company: Brow Raise on a word can have the intensification function, whereas this seems more difficult for Brow Raise before a word. Importantly, in view of our data, we cannot claim that the effect is categorical. Rather, Brow Raise before a word might be a less effective means of intensification than Brow Raise on a word, and this can be compensated for (to some extent at least) by using heightened Brow Raise in a preposed position.

5.2 Initial paradigms with Brow Raise

We first sought to assess how Brow Raise on its own compares to other properties that can help mark focus, as in the paradigm in (16). Throughout, we translate intensified adjectives using capitals in the English version, since the adjective with emphasis allows for the intensified reading; the reader may read these with an explicit modifier (e.g. *very tall*) if they prefer.

(16) (Acceptability of the second word of the sentence.)

PETER _____. JOHN TALL¹⁸.

a. ⁷ TALL

/}Λ

b. ⁷ TALL

/}

c. ^{6.7} TALL

Λ

d. ^{6.7} TALL

Λ-

e. ^{6.7} TALL

Λ-/}

f. ⁷ TALL

'Peter is TALL. John is tall.' (ASL, [35, 1512](#); 3 judgments)

(17) *Inferential question*: How strongly to you derive the inference that (i) John is taller than Peter? (ii) Peter is taller than John? (1 = no inference; 7 = strongest inference)

One infers that	a.	b.	c.	d.	e.	f.
(i) John is taller than Peter	1	1	1	1	1	1
(ii) Peter is taller than John	1	7	7	5.3	2.7	7

Starting from a neutral realization of *TALL* in (16)a, we added in (16)b a normal emphasis effected by various manual and non-manual means, including Brow Raise. This yielded a clear intensificational effect, diagnosed by way of inferential judgments: in (16)b but not in (16)a, an inference was obtained to the effect that Peter is taller than John. Removing Brow Raise while keeping all other means of emphasis preserved the semantic effect, as seen in (16)c. In (16)d, only Brow Raise was used to emphasize the predicate, with a possibly weakened but still clear intensificational effect (Brow Raise was unintentionally realized in its heightened form). Importantly, Brow Raise before the word did not yield clear intensification, as in (16)e. Comparable judgments were obtained when the order of the predicates was reversed, as in the paradigm in (18) (here too, preposed Brow Raise in (18)e was smaller than Brow on *TALL* in (16)d).

(18) (Acceptability of the last word of the sentence)

JOHN TALL. PETER _____.

a. ⁷ TALL

/}Λ

¹⁸ The version of *TALL* that we used is the first one on the following webpage: <https://www.lifepoint.com/asl101/pages-signs/t/tall.htm>.

b. ⁷TALL

/}_____

c. ^{6.3}TALL

^_____

d. ^{6.7}TALL

^_/______

e. ⁷TALL

^-/}_____

f. ^{6.3}TALL

'John is tall. Peter is tall / TALL.' (ASL, [35.1508](#); 3 judgments)

Anonymized video: <https://youtu.be/vHEZGTBG9K8>

(19) *Inferential question*: same as (17).

One infers that	a.	b.	c.	d.	e.	f.
(i) John is taller than Peter	1	1	1	1	1	1
(ii) Peter is taller than John	1	7	7	6	2.7	7

Two possible conclusions could be drawn at this point. One is that Brow Raise before an expression just cannot intensify it. An alternative is that it can, but that the realization we picked was insufficiently strong. We will now see that more minimal paradigms provide a partial argument for the latter possibility.

5.3 Comparing normal and heightened Brow Raise

The paradigm in (20) assesses the effect on intensificational readings of two parameters: the size of Brow Raise (normal or heightened), and its timing (on or right before an expression). There are two main results: (i) heightened Brow Raise marks intensification better than normal Brow Raise; (ii) the intensificational effect is reduced when Brow Raise occurs before than on a word. This is diagnosed by the strength of the inference that Peter is taller than John.

(20) (Acceptability of the second word of the sentence)

PETER _____ . JOHN TALL.

a. ⁷TALL

^_____

b. ^{6.7}TALL

^_____

c. ^{6.7}TALL

^_/______

d. ⁷TALL

^-/_____

e. ^{6.7}TALL

'Peter is tall / TALL. John is tall.' (ASL, [35.1504](#); 3 judgments)

Anonymized video: https://youtu.be/-fRd_wSaRvg

(21) *Inferential question* (as in (17))

One infers that	a.	b.	c.	d.	e.
(i) John is taller than Peter	1	1	1	1	1
(ii) Peter is taller than John	1	4	6	2.7	4

In our initial paradigm in (20), the intensified word comes first. Partly similar effects are obtained when it comes last, as in (22): normal Brow Raise on but not before *TALL* leads to intensification. A bit more clearly than in (20), a heightened Brow Raise before the word does give rise to an intensification-like effect, albeit a reduced one. Brow Raise before *TALL* fails to yield any clear intensification.

(22) (Acceptability of the last word of the sentence)

JOHN TALL. PETER ____.

a. ⁷ TALL

b. ^{6.7} TALL

c. ^{6.7} TALL

d. ⁷ TALL

e. ^{6.7} TALL

'John is tall. Peter is tall / TALL.' (ASL, [35.1500](#); 3 judgments)

Anonymized video: <https://youtu.be/h3ZfTA57tYQ>

(23) Inferential question (as in (17))

One infers that	a.	b.	c.	d.	e.
(i) John is taller than Peter	1	1	1	1	1
(ii) Peter is taller than John	1	5.7	6.7	3	5.3

In (24), we perform similar tests with the ASL word *NEAR*, assessing whether it means *near* or *very near* depending on whether it is intensified.

(24) (Acceptability of the last word of the sentence)¹⁹

IX-1 WANT XI-2 DRIVE ____.

a. ⁷ NEAR

b. ^{6.7} NEAR

c. ⁶ NEAR

d. ⁷ NEAR

e. ⁷ NEAR

'I want you to drive near / NEAR.' (ASL, [35.1254](#); 3+1 judgments)

Anonymized video: <https://youtu.be/5Y8tHF9vWLY>

(25) *Inferential question:*

Indicate with which strength you derive the relevant inferences: 1 = no inference; 7 = strongest inference:

Example: 'near' counts as 2 miles or less, 'very near' counts as 1 mile or less.

In the context of this example, for each of the following distances, do you infer that they are DESIRED? (i) ≤1 mile (ii) between 1 and 2-miles (iii) > 2 miles

Are the following distances desired?	a.	b.	c.	d.	e.
(i) ≤1 mile	7	7	7	7	7
(ii) between 1 and 2-miles	7	3.7	2	5.7	3.7
(iii) > 2 miles	1	1	1	1	1

To facilitate inferences, the written questions explicitly suggested that 'near' counts as 2 miles or less, 'very near' counts as 1 mile or less, which made it possible to ask by way of multiple choice questions which distances are desired: (i) ≤1 mile (ii) between 1 and 2 miles (iii) >2 miles. Contrasts were found: without emphasis, as in (24)a, *NEAR* allows for options (i) and (ii) (but not (iii)). With normal or heightened Brow Raise on *NEAR*, as in (24)b,c, option (ii) becomes less

¹⁹ Since the first inferential judgment task on this question was binary (yes/no) rather than quantitative, we only provide information about the last three judgment tasks, which involved quantitative ratings instead. This also applies to acceptability judgments: for uniformity, we only use the last 3 judgments provided.

acceptable, indicating a 'very near' interpretation. With normal Brow Raise before *NEAR*, as in (24)d, option (ii) becomes more acceptable again, which is indicative of the possibility of a 'near' interpretation. The effect is less clear with heightened Brow Raise before the modified word, as in (24)e: it seems to be somewhat compatible with an intensificational effect.

Similar results were found with *SHORT* in (26), where heightened but not normal Brow Raise yields intensification when it appears before the adjective. We must note that our paradigms were not, despite our best efforts, entirely minimal, since a head nod occurred in (24)d,e and (26)d,e (the fact that we didn't obtain intensification suggests that, in this paradigm at least, a head nod can't have this function).

(26) (Acceptability of the last word of the sentence)²⁰

IX-1 WANT POSS-2 LECTURE ____.

a. ⁷ SHORT

^

b. ⁷ SHORT

^

c. ⁷ SHORT

^_}

d. ⁷ SHORT

^_}

e. ^{6.3} SHORT

'I want your lecture to be short / SHORT.' (ASL, [35, 1256](#); 3+1 judgments)

Anonymized video: <https://youtu.be/xPU5CdqXCqw>

(27) *Inferential question*: Indicate with which strength you derive the relevant inferences: 1 = no inference; 7 = strongest inference:

Example: 'short' counts as 20 minutes or less, 'very short' counts as 10 minutes or less.

In the context of this example, for each of the following durations, do you infer that they are DESIRED? (i) ≤10 minutes (ii) between 10 and 20 minutes (iii) > 20 minutes

Are the following durations desired?	a.	b.	c.	d.	e.
(i) ≤10 minutes	7	7	7	7	7
(ii) between 10 and 20 minutes	7	3.7	2.3	5	3
(iii) > 20 minutes	1	1	1	1	1

In sum, Brow Raise on a gradable expression can serve to intensify it. The intensificational effect is reduced or removed when Brow Raise occurs before an expression. For normal Brow Raise, intensification seems to disappear when the non-manual occurs before the word, but for heightened Brow Raise, a reduced intensificational effect may still be found.

5.4 Interim summary and initial LSF replication

The generalizations obtained are stated in (28).

(28) **Summary of the generalizations**

a. Existence of intensification-related Brow Raise: In our ASL data, Brow Raise can intensify a gradable construction.

b. Distinction between Brow Raise on vs. before a word:

(i) Brow Raise on a word can either mark standard focus (contrastive focus, association with focus) or intensification.

(ii-1) Normal Brow Raise before a word can mark standard focus (contrastive focus and, to some extent, association with focus), but not intensification.

²⁰ Here too, we only provide information about the last three judgment tasks, which involved quantitative judgments, leaving aside inferential and acceptability judgments given in the first judgment task (because its inferential component was based on a yes/no question).

(ii-2) In several ASL cases ((22)e, (24)e, (26)e), heightened Brow Raise in a preposed position can (unlike normal Brow Raise) mark intensification.

As we show in Appendix II, we replicated similar contrasts pertaining to generalizations (28)a,b(i)-(iia) in several LSF paradigms (but without being in a position to make claims about the generality of this phenomenon).

6 An analysis within Alternative Semantics

To derive the data within Alternative Semantics, we adopt Rooth's (1996) semantics for focus, and we assume that Brow Raise forces the appearance of F-marking (which generates alternatives) on the expression it modifies. But in order for Brow Raise to have an intensificational reading as well, we need to add something to Alternative Semantics. We propose to posit that Brow Raise makes a semantic contribution of its own, which we call 'noteworthiness'. The semantics is set up in such a way that this 'noteworthiness' contribution will make itself felt with gradable constructions, but will usually be vacuous in other cases.

(29) Main assumptions

- a. Brow Raise before an expression exclusively (or preferentially) F-marks the entire expression it modifies.
- b. Brow Raise before a gradable expression can either (i) F-mark the entire expression, or just (ii) its degree variable.
- c. Brow Raise makes a semantic contribution of its own, indicating that the asserted clause is 'noteworthy' relative to its set of alternatives. We define 'noteworthy' as: 'not entailed by most of its alternatives'

To avoid writing formulas on two lines simultaneously, we will write $\wedge E$ for Brow Raise on an expression E , and $\wedge\text{-}E$ for Brow Raise before an expression E .

The key assumptions are in (29)b,c. Per (29)b, a sign language expression such as *PETER* \wedge *TALL*, with Brow Raise on (rather than before) *TALL*, can receive an analysis of the form *Peter is (at least) d_F -tall*, with focus marking on the degree argument. Per (29)c, Brow Raise introduces a noteworthiness requirement. When the F-marked expression is not a member of a neo-Gricean scale, the noteworthiness requirement will usually be vacuously satisfied and the net effect will reduce to focus marking. When a degree variable is F-marked, the requirement won't be trivial: for *Peter is (at least) d_F -tall*, the noteworthiness requirement is that the clause should not be entailed by most of its degree alternatives, and hence Peter's degree of height should lie within the upper part of the scale, hence the intensificational effect observed.²¹

We turn to a more precise definition of our focus-related notations. (30) recapitulates the standard view (e.g. Rooth 1996) that expressions have an ordinary value and a focus value, combined with ordinary assumptions and notations from semantics (e.g. the evaluation of expressions under an assignment function s and world parameter w).

- (30) a. $[[\bullet]]^{s,w,o}$ is the ordinary value of \bullet under assignment s and in world w
 b. $[[\bullet]]^{s,w,f}$ is the focus value of \bullet under assignment s and in world w (technically, $[[\bullet]]^{s,w,o}$ and $[[\bullet]]^{s,w,f}$ are short for $[[\bullet]]^{s,o}(w)$ and for $[[\bullet]]^{s,f}(w)$).
 c. Focus values are defined, as in Rooth 1996, as sets of semantic objects. D is the set of entities, Deg is a (contextually specified) finite set of degrees, $Property$ is a (contextual specified) finite set of properties (of type $\langle s, \langle e, t \rangle \rangle$).
 d. As is standard, if s is an assignment function, $s[d \rightarrow d^*]$ is the function that is identical to s , with the possible exception that it assigns d^* to the variable d (in the discussion below, d will be a degree variable).

²¹ We take the noteworthiness requirement to be associated with further means of emphasis as well, since in our data manual intensification gives rise to semantic effects. Brow Raise is special and theoretically informative because it can both co-occur with an expression and precede it.

e. We write as *tall'* and *Peter'* the semantic values of *TALL* and *PETER* respectively, and adopt related conventions for other expressions.

In our general theoretical machinery, we adopt a standard rule of extensional function application whereby if F is a functor and A is its argument, $[[F A]]^{s,w,o} = [[F]]^{s,w,o}([[A]]^{s,w,o})$. Focus semantic values are defined by the procedure specified in (31), from Rooth 1996.

- (31) a. The focus semantic value of a focused phrase of semantic type τ is the set of possible denotations of type τ .
 b. The focus semantic value of a non-focused lexical item is the unit set of its ordinary semantic value.
 c. Let α be a non-focused complex phrase with component phrases $\alpha_1, \dots, \alpha_k$ and let Φ be the semantic rule for α , e.g. function application. The focus semantic value of α is the set things obtainable as $\Phi(x_1, \dots, x_k)$, where $x_1 \in [[\alpha_1]]^f$ and \dots and $x_k \in [[\alpha_k]]^f$.

Turning to our specific theoretical machinery, our assumptions about focus-marking, Brow Raise and gradable constructions are stated in (32), which just adapt to Alternative Semantics the general ideas we introduced in (29). In particular, (30)a states that Brow Raise on an expression can F-mark the entire expression or a degree variable it contains. (32)b states that the semantic contribution of Brow Raise is to add a requirement that $A(x)$ is noteworthy within its set of alternatives $A'(x)$, $A''(x)$, etc.

- (32) In a constituent $[...^{\wedge}A...]$ with $A = E$ (i.e. \wedge is on E) or $A = -E$ (i.e. \wedge precedes E):²²
 a. formally, E must be F-marked if $A = -E$ (i.e. if \wedge precedes E), and E must be F-marked *or contain an F-marked element* (such as a degree variable) if $A = E$ (i.e. if \wedge is on E);
 b. semantically, if E is of predicative type, for any expression A (which could be of the form E or $-E$),
 $[[^{\wedge}A]]^{s,w,o} = \lambda x. [[A]]^{s,w,o}(x) = 1$ and noteworthy($\lambda w_s. [[A]]^{s,w,o}(x), \{\lambda w_s. P(w)(x): P \in [[A]]^{s,f}\}$).

(33)a explicates that a proposition is noteworthy just in case most of its alternatives don't entail it. (33)b,c introduce standard assumptions about gradable adjectives: *tall* is gradable and comes with a degree argument, while *French*, which isn't gradable, doesn't have a degree argument. (33)d makes the simplifying assumption that there is a finite number of degrees (so we can easily define what it means for something to hold of 'most' of them).

- (33) a. If p is a proposition and Π is a finite set of propositions, noteworthy(p, Π) iff (= if and only if) most members of Π fail to entail p .
 b. *TALL* is represented as *d-TALL*, with a degree variable d as argument. It has the lexical entry:
 $[[TALL]]^{s,w,o} = \lambda d \lambda x \ x$ is at least d -tall in $w = \lambda d \lambda x \ \text{tall}'(w)(d)(x)$.
 c. *FRENCH* does not take a degree variable as an argument, and it has the lexical entry:
 $[[FRENCH]]^{s,w,o} = \lambda x \ x$ is French in $w = \lambda x \ \text{french}'(w)(x)$
 d. Simplifying assumption: we assume that the set of degrees is finite (to avoid comparing the size of infinite sets).

Let us now see how this analysis derives the intensified reading of $^{\wedge}TALL$, with Brow Raise on the predicate. This makes two patterns of F-marking possible: on the entire predicate, or on its degree variable. We consider the latter option first. The outcome will be that Peter is tall to a degree d^* which is above d_{half} , the middle of the scale of degrees.

Let us start with (a sketch of) the computation of the ordinary value and of the focus value of d_F -*TALL*. It will be useful to make separate assumptions about the computation of the focus

²² In our computations below, we take $-$ to be semantically vacuous (it just marks that Brow Raise is before an expression, which in turn has consequences for F-marking possibilities, hence an *indirect* effect on interpretation).

value of d_F -*TALL*, as in (34)b (these values will be relativized to a world parameter s in the ensuing computations).

- (34) a. $\llbracket d_F$ -*TALL* $\rrbracket^{s, \circ} = \lambda w. \llbracket d_F$ -*TALL* $\rrbracket^{s, w, \circ} = \lambda w. \llbracket \text{TALL} \rrbracket^{s, w, \circ}(\llbracket d_F \rrbracket^{s, w, \circ}) = \lambda w. \text{tall}'(w)(s(d))$
 b. $\llbracket d_F$ -*TALL* $\rrbracket^{s, \circ} = \{\lambda w'. \text{tall}'(w')(d') : d' \in \text{Deg}\}$

We assume that the degree variable of *TALL* is existentially closed as in the LF in (35)a, whose truth conditions are sketched in (35)b, and made more precise in Note 1 of Appendix I; the result is that Peter's degree of height should be above the middle of the scale.

- (35) a. $\exists d \text{ PETER} \wedge [d_F$ -*TALL*]
 b. $\llbracket (a) \rrbracket^{s, w, \circ} = 1$
 iff for some degree d^* , $\llbracket \text{PETER} \wedge [d_F$ -*TALL* $\rrbracket \rrbracket^{s[d \rightarrow d^*], w, \circ} = 1$,
 iff for some degree d^* , Peter is tall to degree d^* , and this is noteworthy relative to (degree-) alternatives to this proposition,
 iff for some degree d^* , Peter is tall to degree d^* , and most (degree-) alternatives to this proposition do not entail it,
 iff for some degree d^* , Peter is tall to degree d^* and d^* is above most degrees of height.

It is clear that the analysis could be tweaked by changing the meaning of *noteworthy*: if one requires that a proposition is noteworthy relative to a set of propositions just in case it is entailed by less than 10% of them (rather than less than 50% of them, as in our definition), the intensificational effect will be strengthened (as d^* will have to be within the top 10% of degrees).

We now consider the case in which \wedge triggers F-marking on the entire expression it associates with – which is the only (or preferred) possibility when Brow Raise precedes an expression. The outcome will be that the noteworthiness requirement is typically trivialized because most of the alternative propositions do not stand in an entailment relation anyway. The derivation is sketched in (36) and made more precise Note 2 of Appendix I. Since the noteworthiness requirement is trivialized in this case, if F-marking must be justified by something, we will presumably end up with whatever informational effects are produced by focus in standard cases, and in particular F-marking may be justified by a contrast, or by association with an operator.²³

- (36) a. $\exists d \text{ PETER} \wedge [d$ -*TALL*]_F
 b. $\llbracket (a) \rrbracket^{s, w, \circ} = 1$ iff for some degree d^* , $\llbracket \text{PETER} \wedge [d$ -*TALL*]_F $\rrbracket^{s[d \rightarrow d^*], w, \circ} = 1$,
 iff for some degree d^* , Peter is tall to degree d^* , and this is noteworthy relative to predicate alternatives to this proposition (obtained by replacing *tall* with other adjectives)
 iff for some degree d^* , Peter is tall to degree d^* , and most predicate alternatives to this proposition, of the form *Peter is French, Peter is English, etc. do not entail it*,
 iff for some degree d^* , Peter is young to degree d^* (as the underlined requirement is vacuous).

Importantly, the present analysis predicts a categorical distinction between Brow Raise before vs. on an adjective: only the latter should yield an intensificational reading. This is not quite correct, since in our data heightened Brow Raise can sometimes yield an intensificational reading. As things stand, this is a limitation of our analysis (see also Note 3 of Appendix I).

In sum, we can capture our main data within Alternative Semantics, but we must stipulate that Brow Raise doesn't just serve, in these cases at least, to F-mark expressions, but that it also makes a semantic contribution of its own ('noteworthiness'). The repercussions of these assumptions would need to be assessed in greater detail. In addition, our analysis does not capture the fact that proposed Brow Raise can to some extent fulfill an intensification function if it is heightened.

²³ Note that in a more complete treatment we should allow F-marking to associate with several operators (or else the noteworthiness operator introduced by Brow Raise would block association with further operators such as *ONLY*).

7 An analysis in terms of noise-reduction

Bergen 2016 develops a unified analysis of focus and intensification within the Rational Speech Act model. As he notes, Alternative Semantics offers an account of the effect of stress analyzed as focus-marking for the examples in (1) but not for the various cases of strengthening found in (2). The fact that Brow Raise has the focus-related functions in (1) and can also strengthen adjectives provides an additional argument for Bergen's view that these should be treated as a partly unified phenomenon (we write '*partly unified*' to take into account Wagner's objection: Bergen's theory needs to be supplemented with a mechanism to explain why prominence must shift in focus-related cases but not in intensification). While we argued in the previous section that the Brow Raise data can be analyzed within Alternative Semantics, this was at the cost of positing a new operator ('noteworthiness') associated with Brow Raise.

While our first finding – Brow Raise can have focus-related and intensificational uses alike – strengthens Bergen's argument, the contrast between Brow Raise on vs. before an expression requires a detailed discussion. A full model lies beyond the scope of this paper, but we will develop a simplified version of Bergen's analysis, and show that with some auxiliary hypotheses (which are arguably plausible) the data can be derived. We discuss a concrete case in this section, referring the reader to Appendix III for a slightly more general treatment. Importantly, we develop the analysis with full rather than bounded rationality, which greatly simplifies computations (Bergen uses bounded rationality instead).

7.1 A simplified version of Bergen's analysis

We start by summarizing a simplified Bergenian analysis of two cases: exhaustification as in (1)c, and adjectival strengthening as in (2)a.

Consider the case of *Sam will invite Ann OR Bill*. Bergen's goal is to derive the exclusive (exhaustive) reading by pragmatic means, without positing an exhaustivity operator in the syntax. Bergen's starting point is that there is always a small risk of signal corruption, whereby *or* could be misheard as *and* (the probability may be very small). One can decrease this risk by stressing the word, yielding a benefit, which we will call *b*. But this comes at a slight cost, which we will call *c*. If the speaker is entirely rational (which isn't the case in Bergen's actual analysis), it's only worth reducing the risk of corruption if the benefit derived in so doing is greater than the cost, i.e. if $b > c$. Now we consider two situations:

Situation 1: the speaker knows that Sam will invite one of {Ann, Bill} but not both.

Situation 2: the speaker doesn't know whether Sam will invite just one or both of {Ann, Bill}.

It is clear that the speaker will consider the risk of misperception of *or* as *and* as being worse in Situation 1, where it provides clearly incorrect information, than in Situation 2, where it might provide correct information. Thus the use of stress will tend to be associated with Situation 1 and for this reason it will come with an exclusive inference akin to exhaustification (whereby *p or q* is strengthened to *p or q but not both*). The addressee who takes this into account will thus increase her belief (i.e. her probability) that *or* was used exclusively. And the speaker who takes into account the addressee's behavior may thus use stress to signal exhaustification. Formalizing this reasoning requires a detailed analysis within the Rational Speech Act model, as developed by Bergen.

The reasoning is rather similar with adjectival strengthening. Following the literature, Bergen assumes that *tall* and *short* come with contextually determined thresholds, so that *Bob is tall* is deemed true just in case his height is above the height threshold θ_{tall} , and *Bob is short* is true just in case his height is below a threshold θ_{short} . The values of θ_{tall} and θ_{short} are not known with certainty, but not anything goes: it is very likely that 1m90 counts as being above the 'tallness' threshold θ_{tall} , while 1m75 might or might not be above the threshold. Similarly, 1m60 is very likely to count as being below the 'shortness' threshold θ_{short} , whereas 1m75 might or might not be

below that threshold. Here too, there is a risk that *tall* might be misperceived as *short*, but the risk can be mitigated, with a benefit b , in case the speaker stresses the word, at a cost c – which is worth doing if $b > c$. We consider the sentence *Bob is tall*, and we consider once again two situations:

Situation 1: the speaker knows that Bob is very tall, e.g. 1m90.

Situation 2: the speaker knows that Bob is just tall, e.g. 1m75.

In Situation 1, if *tall* gets misperceived as *short*, the addressee will almost certainly form incorrect beliefs, as the threshold for *short* is unlikely to classify 1m90 as short. In Situation 2, the risk that the addressee forms incorrect beliefs is a bit smaller, because there is a greater chance that the threshold for *short* classifies 1m75 as short. For instance, Bob might count as tall if his height is $\geq 1m70$, while he might count as short if his height is $\leq 1m75$, and the overlap would ensure that if *tall* is misheard as *short*, no incorrect beliefs are formed in this case.

As a result, the speaker will tend to use stress more in Situation 1 than in Situation 2. The addressee that takes into account the speaker's behavior will thus tend to associate stress on *tall* with 'very tall' situations. And the speaker S who takes into account this behavior on the addressee's part will be able to signal that S has in mind a 'very tall' situation by stressing the adjective. Here too, the details, which are complex, are worked out in Bergen 2016.

7.2 *Brow Raise and noise reduction*

Bergen 2016 notes that "there are three main acoustic changes associated with prosodic stress: increased loudness, duration, and changes to the fundamental frequency [Breen et al. 2010]. An utterance that is louder and longer is less likely to get swamped by sounds in the environment, while changes in pitch will focus the addressee's attention on the utterance."

In line with these two types of noise reduction (increasing signal clarity and focusing the addressee's attention), the role of Brow Raise may be viewed in two ways. As noted in Section 1.2, Sandler 2011 argues (following Dachkovsky) that Brow Raise has the same semantic function as "the High boundary tone in many spoken languages" (Sandler 2011; Dachkovsky 2005, Dachkovsky and Sandler 2009), which in turn might be consonant with Bergen's discussion of the salience-related effect of higher pitch.²⁴ Independently, one could postulate that Brow Raise might be a signal that one's eyes need to be widened, which in turn has been shown to enhance stimulus detection (Lee et al. 2014): this might lie at the source of the signal that the relevant part of the message is particularly important. In this way, Brow Raise might reduce noise by focusing the addressee's attention on a particular part of the message.

The noise-reduction analysis can be further strengthened by noting that, in our data, Brow Raise is part of a cluster of properties that includes several other manual or non-manual modifications such as forward lean, greater sign amplitude, and head nod, as discussed above. This can be seen in two ways. First, when the consultant was asked to realize emphasis on a word with all available means, these did not just include Brow Raise, and the result was at least as acceptable as with Brow Raise alone, as can be seen for focus in (10)b, (9)b, (12)b, (14)b, and for intensification in (16)b and (18)b. In particular, the latter two cases involved the following form, with not just heightened Brow Raise, but also a forward lean, a head nod and increased amplitude.

(37) $\uparrow\Lambda$
TALL

Second, using these other means to the exclusion of Brow Raise sometimes lead to acceptable results as well: this was the case for focus in (9)c (whereas for reasons we don't understand (10)c was more degraded) and for intensification in (16)c and (18)c. And just as in Bergen's description

²⁴ Since tones cannot be realized before a word whereas Brow Raise can, the latter makes it possible to test options that are probably not afforded by high boundary tones.

of the English acoustic facts, some of these means (such as greater sign amplitude) can be taken to help with sign perception, while as mentioned Brow Raise might indicate that the addressee should pay special attention to a certain part of the message. Head nods might fall in the latter category as well, while forward leans might fall in the first category if one thinks that by moving closer to the addressee one is making the sign easier to perceive.

Despite these arguments for the noise-reduction analysis, Bergen's view is faced with two challenges. First, Wagner's objection shows that focus involves prominence shift but intensification does not: for spoken language at least, a component must be added to Bergen's analysis to account for deaccenting. Second, Bergen's unitary analysis must explain why focus but (usually) not intensification is compatible with Brow Raise before the target expression.

7.3 *Sketch of a noise-based account*

Without providing a full account, we will sketch a general direction, mentioned by Leon Bergen (p.c.). The main ideas are as follows.

- (i) Brow Raise before an expression is a less efficient way of reducing noise than Brow Raise on an expression. Why this is would need to be determined, but we can note that Brow Raise before an expression is plausibly much shorter than Brow Raise on an expression, simply because in the latter case it must span the duration of at least one word.²⁵
- (ii) Brow Raise before an expression is less costly than Brow Raise on an expression. Here too, one might invoke shorter duration to justify the difference (this is in part speculative since duration isn't the only thing that enters into cost).
- (iii) Under certain conditions, (i) and (ii) balance each other out and one can thus optionally use Brow Raise on or before an expression; this is the case of focus-related uses.
- (iv) When the benefit of reducing noise is greater, Brow Raise on an expression wins out; this is the case of intensificational uses.
- (v) When the benefit of reducing noise is too low, it does not outweigh the cost of using Brow Raise, and no Brow Raise is used; this is the case for expressions that neither involve focus nor intensification.

To make things concrete, we will consider a single sentence, *PETER TALL*, which could be used in three kinds of situations depending on the Question under Discussion (QUD) and the speaker's state of knowledge.

Intensificational situation: The QUD is {PETER TALL, PETER SHORT}, and the speaker knows that Peter is very tall.

Focus situation: The QUD is {PETER TALL, PETER SHORT}, and the speaker has no knowledge about how tall Peter is (but knows that Peter is tall).

Unmarked situation: The QUD is {PETER TALL, PETER SHORT, PETER FRENCH}, and the speaker has no knowledge about how tall Peter is (but knows that Peter is tall).

In each case, we need to compute the trade-off between the cost and the benefit of reducing noise. Here we assume for simplicity, that perception errors transform one element of the QUD into another (in other words, misperception is constrained by knowledge of the QUD). We can then order the cases of misperception as follows:

²⁵ To give an example, in (12)c,d, where Brow Raise appears on a pronoun, duration was of approximately .8s and 1s. By contrast, in (12)e,f, where Brow Raise appears right before the pronoun, duration was of approximately .2s and .3s.

Strong error: The worst case of misperception arises in the intensificational situation. If *PETER TALL* is perceived as *PETER SHORT*, and the speaker knows that Peter is very tall, the information conveyed will most likely mislead the addressee about the state of the world.

Medium error: A less severe case of misperception arises in the focus situation: if *PETER TALL* is misperceived as *PETER SHORT*, but the speaker doesn't know how tall Peter is, the information will probably but not necessarily contradict the state of the world. There is a situation in which the threshold for *TALL* is $\geq 1m70$, the threshold for *SHORT* is $\leq 1m75$, and Peter's actual height ranges from 1m70 to 1m75. In this case, misperceiving *TALL* as *SHORT* won't be as catastrophic as in the intensificational situation.

Weak error: Still less severe is the case of misperception that arises in the unmarked situation. Here two things could happen when *PETER TALL* is misperceived: it could be misperceived as *PETER SHORT* (say half the time), or as *PETER FRENCH* (half the time as well). In the first case, we get the same result as in the focus situation: the message conveyed will probably but not necessarily mislead about the state of the world. In the second case, the message conveyed is orthogonal to what the speaker intended, and thus it may or may not mislead about the state of the world. Since misleading is in this case less likely than in the case in which *TALL* was turned into *SHORT*, this is overall a less severe case of misperception than in the focus situation.

Still to make things concrete, we'll assign numbers to these situations, assuming that the benefit is 3 if information is transmitted without error, and less than 3 if a perception error arises: 2 in situation of weak error, 1 in situations of medium error, and 0 in situations of strong error, as summarized in (38) (in a 'real' Rational Speech Act model, these values would be derived from the effect of different forms on the addressee's beliefs).

(38) Assumptions about the benefit of rightly vs. wrongly transmitting the message in different situations

Situation	Benefit if the target expression is rightly perceived	Benefit if the target expression is wrongly perceived
Strong error	3	0
Medium error	3	1
Weak error	3	2

We further need to specify how the chance of an error is affected by means of noise-reduction, here Brow Raise. We will see that with the assumptions in (39) we derive the desired results, namely that Brow Raise on an expression will be used in intensificational situations, Brow Raise on or before an expression will be used in focus situations, and no Brow Raise will be used in neutral situations (see Appendix III for a more general treatment).

(39) Assumptions about the cost and effect of noise-reduction

Description	Example	Probability of misperception	Cost
Unmarked expression	• TALL	.4	0
Brow Raise before the expression	^_____ • TALL	.2	.3
Brow Raise on the expression	^_____ • TALL	0	.7

These assumptions can be described as follows. Brow Raise on an expression is most efficient in reducing the risk of misperception – for simplicity, we take it to reduce the risk to 0. Next, Brow Raise before an expression leaves a 20% risk of misperception, followed by the absence of Brow

Raise, yielding a 40% risk of error (we assign these probabilities for simplicity; real values are undoubtedly far smaller). The ordering by cost is the opposite: using no Brow Raise is free, Brow Raise before an expression has a cost of .3, Brow Raise on a word has a cost of .7. As mentioned, the differences in cost and efficiency might be justified on the basis of duration, although this is currently speculative.

We now need to compute the costs and benefits of *TALL*, \wedge *TALL* and \wedge -*TALL*. It will help to introduce some notations to refer to the cost of an expression e ($= c(e)$), to the probability it will be incorrectly perceived ($= p(e)$), and to the benefit obtained if the target expression is correctly perceived in a situation s ($= b^+(s)$), as well as the benefit obtained if the target expressions is incorrectly perceived in s ($= b^-(s)$). These notations are summarized in (40). (We write $b^+(s)$ and $b^-(s)$ rather than $b^+(e, s)$ and $b^-(e, s)$ because the benefits are the same for *TALL*, \wedge -*TALL*, \wedge *TALL*, and thus do not depend on the expression e . This is because the three expressions have the same literal meaning, and thus the only thing that matters for the benefit they yield is whether or not they are correctly perceived. What differs across the three expressions is their cost, and the probability that they are incorrectly perceived.)

- (40) $c(e)$ = cost of an expression e (e.g. *TALL*, \wedge -*TALL*, \wedge *TALL*)
 $p(e)$ = probability that e will be incorrectly perceived
 $b^+(s)$ = benefit if the expression is perceived correctly in situation s ($= 3$ in all cases)
 $b^-(s)$ = benefit if the expression is perceived incorrectly in situation s ($= 0, 1$ or 2 depending on the case)

Now a signer that must choose an expression within the set $\{TALL, \wedge$ -*TALL*, \wedge *TALL* $\}$ has to balance the expected benefits and costs. The expected benefit of using an expression e in situation s is just the sum of the benefit obtained if e is correctly perceived and of the benefit obtained if e is incorrectly perceived, weighted by the relevant probabilities. The cost is just the cost of the expression, and the expected utility $U(e, s)$ is the difference between the expected utility and the cost. This is expressed in (41), where the third line is obtained by using the fact that in all cases $b^+(s)$, the benefit obtained if the expression is correctly perceived, is of 3 (as specified in the second column of (38)).

- (41) $U(e, s)$ = [expected benefit of e in s] - [cost of e]
 $= [(1-p(e))*b^+(s)] + p(e)*b^-(s)] - c(e)$
 $= [(1-p(e))*3 + p(e)*b^-(s)] - c(e)$
 $= 3 - p(e)[3 - b^-(s)] - c(e)$

To illustrate, consider the expected utility when one uses \wedge -*TALL* ($=$ Brow Raise before the word) in a situation of medium error ($=$ a focus situation). Per (38)-(39), the probability of misperception is $p(e) = .2$, and the benefit when there is a misperception is $b^-(s) = 1$ (otherwise the benefit is 3). The cost of using this expression is $c(e) = .3$. So the expected utility is:

- (42) Expected utility of using $e = \wedge$ -*TALL* in a situation s of medium error
 $U(e, s) = 3 - p(e)[3 - b^-(s)] - c(e)$
 $= 3 - .2[3 - 1] - .3$
 $= 3 - .4 - .3$
 $= 2.3$

Similarly, if one uses \wedge *TALL* ($=$ Brow Raise on the word) in the same situation, the benefits remain the same, but the probability of error and the cost change: the probability of error goes down to 0, while the cost goes up to .7. In this very special case, we obtain the same expected utility as for \wedge -*TALL*, which derives an optionality in this case, as shown in (43) (the second line is obtained by noting that the probability of error $p(e)$ is now set to 0).

- (43) Expected utility of using $e = \wedge$ *TALL* in a situation s of medium error
 $U(e, s) = 3 - p(e)[3 - b^-(s)] - c(e)$

$$= 3 - .7$$

$$= 2.3$$

The expected utilities with the values in (38)-(39) are computed in (44), with maxima boldfaced in each column.

(44) Utilities derived from (61) with the parameters in (68) (maximal utilities in a given column are boldfaced)

	Cost	Perceived word	Probability of wrong/right transmission	Benefits: situations of strong/medium/weak error	Utility = expected benefit - cost = $3 - p(e)[3 - b(s)] - c(e)$		
					Intensificational situation: strong error	Focus situation: medium error	Unmarked situation: weak error
TALL	0	wrong	$p_2 = .4$	$b(s) = 0 / 1 / 2$	$3 - 3p_2 = 3 - 1.2 = 1.8$	$3 - 2p_2 = 3 - .8 = 2.2$	$3 - p_2 = 3 - .4 = \mathbf{2.6}$
		right	$(1 - p_2) = .6$	$b^+(s) = 3$			
\wedge -TALL	$c_1 = .3$	wrong	$p_1 = .2$	$b(s) = 0 / 1 / 2$	$3 - 3p_1 - c_1 = 3 - .6 - .3 = 2.1$	$3 - 2p_1 - c_1 = 3 - .4 - .3 = \mathbf{2.3}$	$3 - p_1 - c_1 = 3 - .2 - .3 = 2.5$
		right	$(1 - p_1) = .8$	$b^+(s) = 3$			
\wedge -TALL	$c_2 = .7$	right	1	$b^+(s) = 3$	$3 - c_2 = 3 - .7 = \mathbf{2.3}$	$3 - c_2 = 3 - .7 = \mathbf{2.3}$	$3 - c_2 = 3 - .7 = 2.3$

As desired, in a situation of strong error (i.e. an intensificational situation), Brow Raise on the expression maximizes utility: the utility obtained with \wedge TALL, 2.3, is higher than the utility that would be obtained with \wedge -TALL (= 2.1) or TALL (= 1.8). In a situation of medium error (i.e. a focus situation), Brow Raise on and before an expression are equal winners: both yield utility 2.3, which is higher than the utility obtained without Brow Raise (= 2.2). Finally, in an unmarked situation, maximal utility is obtained by not using Brow Raise at all: this yields utility 2.6, whereas \wedge -TALL and \wedge TALL yield utilities 2.5 and 2.3 respectively. While this just describes the speaker's association between situations and signals, the addressee who takes into account the speaker's reasoning will come to the same associations.

These results amount to an existence proof that, in a highly simplified framework, the desired results can be derived. Furthermore, the auxiliary hypotheses needed are not outlandish: positing that Brow Raise before an expression is both less costly and less efficient (to reduce noise) than Brow Raise on an expression makes some sense, especially because of its smaller duration.

There are many open questions in this analysis, as is explained in Appendix III, but it could prove fruitful in the future. Importantly, Bergen's theory might be better positioned than our alternative-based analysis to explain why heightened Brow Raise can often intensify adjectives when it is preposed. The reason is that heightened Brow Raise might, at a cost, increase the benefit of the preposed version of Brow Raise, thus making its behavior closer to that of Brow Raise on an expression.²⁶

Addressing these fine-grained questions will require a detailed quantitative investigation that is beyond the scope of this paper.

8 Extension: focus and intensification in an ASL iconic construction

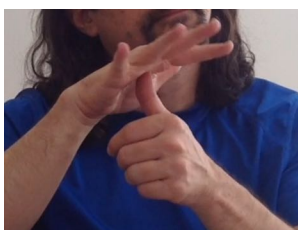
We briefly extend our findings to constructions that are highly iconic. We consider a classifier predicate representing a helicopter movement, and show that Brow Raise on a part of the movement can have intensificational uses, but Brow Raise before doesn't lend itself to such an interpretation.

We start from the iconic description of a helicopter movement with a helicopter-denoting classifier predicate, represented in its neutral form in (45). Classifier predicates are conventional words whose position or movement can iconically represent that of the denoted object (e.g.

²⁶ Depending on one's assumptions, one might also expect that heightened Brow Raise on a word indicates greater intensification than normal Brow Raise on that same word.

Emmorey and Herzig 2003, Zucchi 2011, Davidson 2015). In other words, the lexical form is conventional, but its position or movement is not and yields precise iconic information about the position or movement of the denoted object.²⁷ In our paradigm, the expression is first introduced in its neutral form, glossed as *HELICOPTER*, with a nominal use ('your helicopter'), before appearing as a verbal classifier predicate to represent the helicopter movement, glossed as *HELICOPTER-FLY*.

(45) HELICOPTER classifier predicate



In the paradigm in (46), *HELICOPTER-FLY* traces the path of the helicopter, starting low on the signer's dominant side, ascending and circling, then moving horizontally to the non-dominant side, circling again, before landing. With the standard convention that *a* is on the signer's dominant side and *b* on his non-dominant side, we gloss this iconic movement by way of its four corners as $a_{low} a_{high-stationary} b_{high-stationary} b_{low}$; but it should be remembered that this is a continuous movement. The helicopter path is represented by four pictures in (47). The paradigm is then constructed by adding Brow Raise either on or before one of the two circling, stationary parts glossed as $a_{high-stationary}$ and $b_{high-stationary}$. Acceptability judgments pertained to the entire sentence, and inferential judgments, which were subtle, were answered in words rather than by way of multiple choice questions (we write *3/4 judgments*, *4/4 judgments*... when an inference was obtained in 3 out of 4 judgment tasks, in 4 out of 4 judgment tasks, etc).

(46) (Acceptability of the entire sentence)
POSS-2 HELICOPTER IX-1 DON'T-WANT _____.
'I don't want your helicopter to

^_____

a. ⁷ HELICOPTER-FLY $a_{low} a_{high-stationary} b_{high-stationary} b_{low}$.
circle [after take-off]_F and before landing!
=> the signer doesn't want the helicopter to circle right after take-off (4/4 judgments)
=> circling before landing might/would be allowed (3/4 judgments)

}^_____

b. ⁷ HELICOPTER-FLY $a_{low} a_{high-stationary} b_{high-stationary} b_{low}$.
circle for longer than normal after take-off and circle before landing!
=> the signer doesn't want the helicopter to circle **for longer than normal** after take-off (4/4 judgments, but in 2/4 judgments with an additional specification: when leaving for another location / if landing is then preceded by circling)
=> limited circling after take-off is permitted (4/4 judgments)

^_____

c. ⁷ HELICOPTER-FLY $a_{low} a_{high-stationary} b_{high-stationary} b_{low}$.
circle after take-off and [before landing]_F!
=> the signer doesn't want the helicopter to circle before landing (1/4 judgment) or: after departure and then before landing (3/4 judgments)

²⁷ There are ongoing debates about the syntax and argument structure of classifier predicates (see for instance Kimmelman et al. 2020 for recent references), but they will not be directly relevant: our main point is just that Brow Raise can appear below the word level in highly iconic constructions.

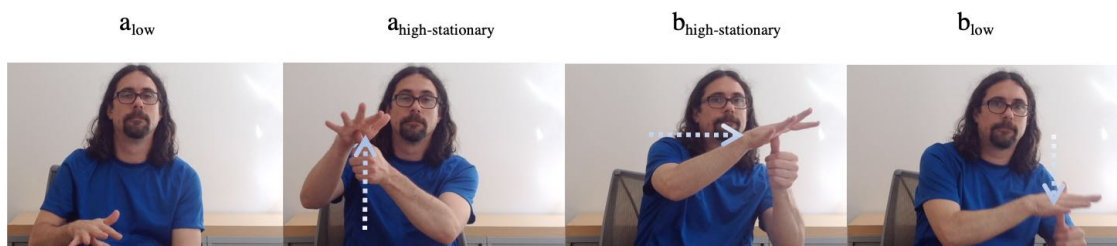
^ _____

d. ⁷ HELICOPTER-FLY_ a_{low} $a_{high-stationary}$ $b_{high-stationary}$ b_{low} .
 circle after take-off and circle for longer than normal before landing!
 => the signer doesn't want the helicopter to circle right after take-off and then **circle for longer than normal** before landing (4/4 judgments)

(ASL, 34, 2756; 4 judgments)

Anonymized video: <https://youtu.be/Zt9i3u7QIAw>

(47) Four moments in the representation of the verb tracing the helicopter's path in (46)a



While the full inferential judgments (found in the Supplementary Materials) are hard to summarize, two striking points emerge. First, when Brow Raise co-occurs with (rather than precedes) one of the two 'high stationary parts', as in (46)b (= Brow Raise on $a_{high-stationary}$) and (46)d (= Brow Raise on $b_{high-stationary}$), the meaning obtained pertains to *longer than normal* circling (as shown in the boldfaced inferences). Thus Brow Raise affects what is inferred about the duration of the denoted events.²⁸ This is probably the same type of intensificational reading as was obtained with Brow Raise co-occurring with gradable expressions in earlier sections.

Second, this intensificational reading disappears when Brow Raise is brief and precedes the 'high stationary parts', as in as in (46)a (= Brow Raise right before $a_{high-stationary}$) and (46)c (= Brow Raise right before $b_{high-stationary}$). In (46)a, we just obtain a reading on which, in the relevant circumstances, circling after take-off is disallowed, with an implication that circling before landing might be allowed. Everything happens as if the particular sequence displayed is disallowed, but with an implicature that an identical sequence without circling after take-off (but with circling before landing) would be allowed. This can be explained if the iconic sign with Brow Raise evokes alternatives obtained by replacing the focused part with some salient expressions, as shown in (48). It is then implicated that although the path as shown is disallowed, an alternative to it displayed by a member of that set is allowed, hence the result.

(48) Formal alternatives to $a_{low} \wedge [a_{high-stationary}] b_{high-stationary} b_{low}$
 $\text{Alt}(a_{low} \wedge [a_{high-stationary}] b_{high-stationary} b_{low}) = \{a_{low} \pi b_{high-stationary} b_{low}: \pi \text{ an alternative to } a_{high-stationary}\}$

For reasons we do not understand, the inferences obtained are more complex in (46)d, but there too it is clear that the 'longer than normal' reading obtained in (46)c does not arise.

If the iconic path of the helicopter is considered as one sign, these results show that focus and intensification can apply at the sublexical level. For focus, this point was made about spoken language by Artstein 2004 in connection with sentences such as (49).

(49) John only brought home a stalagMITE from the cave.

As Artstein writes, "here prominence on the syllable *mite* serves to indicate the restriction on the domain of *only*, in a manner similar to focus on words and higher constituents. The location of

²⁸ It would be important in the future to assess more precisely the duration of the relevant part of the manual sign.

prominence thus has an effect on the sentence's truth conditions: the sentence implies that John did not bring home a stalactite, but does not say anything about what else he might have brought". A similar point is made by (46)a and (46)c. In addition, (46)b and (46)c suggest that intensification too can be applied at the sublexical level.

The paradigm in (46) makes points not made by Artstein's data. First, sub-lexical focus can apply to iconic constructions. This observation highlights the degree to which iconic meanings are integrated with the rest of sign language semantics and pragmatics. The repercussions of the existence of iconic intensification have yet to be explored. The possibility of sublexical focus in iconic constructions suggests that any theory of focus-related alternatives must make provisions for alternatives to iconic representations, as was sketched in (48).

This result might dovetail with work on iconic gestures: Schlenker 2019 discusses implicatures triggered by speech-replacing ('pro-speech') gestures such as those in (50).

(50) a. Robin isn't *VERY-BIG* 
=> Robin is big

b. Robin isn't *VERY-TALL* 
=> Robin is tall

These examples are in one respect similar to our helicopter path sentences: they are iconic, and they evoke alternatives that are not explicitly mentioned in the preceding discourse.²⁹ Specifically, Schlenker 2019 suggests that the alternatives evoked are obtained by replacing *VERY-BIG* and *VERY-TALL* by the sub-gestures representing just *BIG* and *TALL*. By standard Gricean reasoning, the alternatives *Robin isn't BIG* and *Robin isn't TALL* are understood to be denied, hence the inference that Robin is big or tall, as the case may be. Here too, a theory of iconic alternatives is crucial.³⁰

Finally, Brow Raise co-occurring with the 'circling' parts of the path might be an instance of a sublexical intensification, which should be of interest in its own right.

9 Conclusion

9.1 Results and limitations

It goes without saying that our generalizations should be tested with further ASL consultants (our LSF data reported in Appendix II are particularly preliminary, since we just argue that there are

²⁹ Tieu et al. 2019 provide experimental results on gestural implicatures, but in all their cases the alternatives are mentioned in the preceding discourse.

³⁰ Schlenker 2019 speculates on a more subtle point: the more complex gestures *VERY-BIG* and *VERY-TALL* seem to evoke, even in the absence of context, the sub-gestures *BIG* and *TALL*, but the converse might not hold. If so, this argues for the extension to the iconic case of an asymmetry derived by Katzir 2007: more complex expressions automatically evoke less complex ones, but not the other way around. This asymmetry is illustrated in (i), where the more complex expression *drink a lot* evokes the less complex expression *drink* (hence the implicature in (ib), but not conversely (hence the absence of an implicature in (ia)).

- (i) a. I drank.
=> I didn't drink a lot
b. I didn't drink a lot.
=> I drank

some cases that replicate our main ASL generalizations); further examples should be investigated, especially in cases in which our paradigms were not as minimal as we had hoped. Still, we have arguably obtained the following results.

1. Brow Raise doesn't just have information-theoretic uses in ASL (and LSF); in our data, it can also serve to intensify gradable constructions.
2. This can be seen as an argument for the claim in Bergen 2016 that focus and intensification have some properties in common. Bergen wanted to derive them from the same mechanism entirely; but in view of Wagner's objection, partial unification is probably the best we can achieve, as a mechanism must be added to Bergen's analysis to account for deaccenting (which arises with focus but not intensification).
3. While Brow Raise on an expression is ambiguous, normal Brow Raise *before* an expression lacks the intensificational reading. But heightened Brow Raise gives rise to some intensificational reading when it comes before an expression.
4. An analysis can be developed within Alternative Semantics on the assumption that (i) Brow Raise on an expression (but not before one) can focus-mark a degree variable, and (ii) Brow Raise makes a semantic contribution of its own ('noteworthiness'). But our analysis requires positing a new operator, and doesn't account for the possible fact that heightened Brow Raise can marginally have intensificational uses.
5. An alternative can be developed within the noise-reduction-based analysis of Bergen 2016. Within a highly simplified framework, relatively plausible assumptions about the cost and efficiency (in terms of noise reduction) of Brow Raise can derive the desired results.
6. In our ASL data, the dual functions of Brow Raise can be found in highly iconic classifier constructions, and Brow Raise can focus or intensify a subpart of an iconic representation.

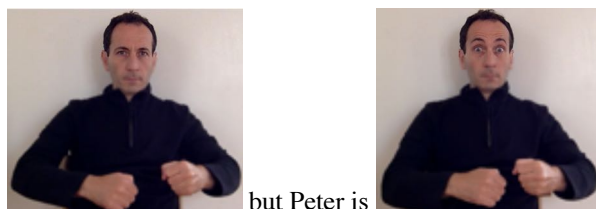
9.2 Future directions

Besides being tested with further consultants, our investigation ought to be extended to further cases of emphasis-based intensification discussed by Bergen 2016, notably exhaustification as in (1)c and effects on quantifier domain restriction in (3).

On a theoretical level, both theoretical directions considered in this piece are highly simplified. The operator we posited within alternative-semantics would need to be refined and independently motivated. As for the noise-reduction analysis, it would need to be developed within Bergen's Rational Speech Act model (which countenances bounded rationality), rather than in the model with perfect rationality we posited for reasons of simplicity.³¹

Several important extensions could be considered in the future.

1. Eyebrow raising is known to mark focus in spoken language (Dohen and Loevenbruck 2009). Can it have intensificational uses as well? We conjecture that it can, at least when it appears on a pro-speech gesture, as in (51): our impression is that the second gesture, with eyebrow raising, lends itself to a meaning akin to 'very big', even when the manual gesture is kept constant.



(51) John is  but Peter is .

³¹ One might also try to treat intensificational Brow Raise on an expression as a marker *sui generis*, e.g. as an iconic modulation (see Schlenker 2018). But this view would fail to explain (i) why intensificational Brow Raise is part of the same cluster of properties that mark focus constructions, and (ii) why heightened Brow Raise before an expression can to some extent fulfill an intensificational function.

Ideally, one would want a detailed study of the focus- and intensification-related uses of Brow Raise on pro-speech gestures (i.e. on gestures that fully replace some words). Since the effects of Brow Raise are typically subtle, this would require a separate study.

2. Is there a broader generalization to the effect that intensificational emphasis must be realized on an expression whereas informational focus can be realized before one? One could explore the behavior of pauses to mark an expression as focused, as in (52).

(52) I only introduced Ann to... Bill.
=>? I didn't introduce other people than Ann to Bill

The question is twofold: (i) can association with focus and contrastive focus be realized in this way? (ii) can intensificational uses be produced with gradable constructions? While (i) requires more work, our impression is that (ii) should receive a negative answer: we believe that an intensificational reading of the second adjective is extremely difficult in (53)b, unlike (53)a.

(53) a. John is tall, but Peter is TALL.
b. #John is tall, but Peter is... tall.

Here too, the data will require a separate study.

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Appendix I. Technical notes

Note 1: more details on the derivation in (35)

In greater detail:

$$\lll[(35a)]\rrr^{s,w,o} = 1$$

iff for some degree d^* , $\lll[\text{PETER} \wedge [\text{d}_F\text{-TALL}]]\rrr^{s[d \rightarrow d^*], w, o} = 1$,

iff for some degree d^* , $\lll[\wedge [\text{d}_F\text{-TALL}]]\rrr^{s[d \rightarrow d^*], w, o}(\text{Peter}') = 1$,

iff for some degree d^* , $[\lambda x. \lll[\text{d}_F\text{-TALL}]]\rrr^{s[d \rightarrow d^*], w, o}(x) = 1$ and noteworthy($\lambda w. \lll[\text{d}_F\text{-TALL}]]\rrr^{s[d \rightarrow d^*], w, o}(x)$,

$\{\lambda w. P(w)(x): P \in \lll[\text{d}_F\text{-TALL}]\rrr^{s, f}\})(\text{Peter}')$ (by (32)b)

iff for some degree d^* , $\lll[\text{d}_F\text{-TALL}]]\rrr^{s[d \rightarrow d^*], w, o}(\text{Peter}') = 1$ and noteworthy($\lambda w. \lll[\text{d}_F\text{-TALL}]]\rrr^{s[d \rightarrow d^*], w, o}(\text{Peter}')$,

$\{\lambda w. P(w)(\text{Peter}'): P \in \lll[\text{d}_F\text{-TALL}]\rrr^{s, f}\})$

iff for some degree d^* , $\text{tall}'(w)(d^*)(\text{Peter}') = 1$ and noteworthy($\lambda w. \text{tall}'(w)(d^*)(\text{Peter}')$, $\{\lambda w. P(w)(\text{Peter}')$:

$P \in \{\lambda w'. \text{tall}'(w')(d'): d' \in \text{Deg}\}$) (the underlined part is obtained by (34)b)

But $\{\lambda w. P(w)(\text{Peter}'): P \in \{\lambda w'. \text{tall}'(w')(d'): d' \in \text{Deg}\}\}$

$= \{\lambda w. \lll[\lambda w'. \text{tall}'(w')(d')](w)(\text{Peter}'): d' \in \text{Deg}\}$

$= \{\lambda w. \text{tall}'(w)(d')(\text{Peter}'): d' \in \text{Deg}\}$

(The second line above, underlined, is obtained by replacing P in the preceding line with all its possible values in the set $\{\lambda w'. \text{tall}'(w')(d'): d' \in \text{Deg}\}$.)

As a result, noteworthy($\lambda w. \text{tall}'(w)(d^*)(\text{Peter}')$, $\{\lambda w. P(w)(\text{Peter}'): P \in \lll[\text{d}_F\text{-TALL}]\rrr^{s, f}\}$

$=$ noteworthy($\lambda w. \text{tall}'(w)(d^*)(\text{Peter}')$, $\{\lambda w. \text{tall}'(w)(d')(\text{Peter}'): d' \in \text{Deg}\}$)

$=$ most members of $\{\lambda w. \text{tall}'(w)(d')(\text{Peter}'): d' \in \text{Deg}\}$ fail to entail $\lambda w_s. \text{tall}'(w)(d^*)(\text{Peter}')$

$= d^* > d_{\text{half}}$ (writing d_{half} for the middle of the scale of degrees)

In the end,

$\lll[\exists d \text{ PETER} \wedge [\text{d}_F\text{-TALL}]]\rrr^{s,w,o} = 1$ iff for some degree $d^* > d_{\text{half}}$, $\text{tall}'(w)(d^*)(p) = 1$.

Note 2: more details on the derivation in (36)

The beginning of the derivation is the same as in (35), so we can take some shortcuts. In accordance with (31)a, we take the focus value of the focused predicate $[\text{d-TALL}]_F$ to be Property, a contextually determined set of properties (of type $\langle s, \langle e, t \rangle \rangle$, e.g. with Property = {french', english', ...}).

$$\lll[(36a)]\rrr^{s,w,o} = 1$$

iff for some degree d^* , $\lll[\text{PETER} \wedge [\text{d-TALL}]_F]\rrr^{s[d \rightarrow d^*], w, o} = 1$,

iff for some degree d^* , $\lll[\text{d-TALL}]_F\rrr^{s[d \rightarrow d^*], w, o}(\text{Peter}') = 1$ and noteworthy($\lambda w. \lll[\text{d-TALL}]_F\rrr^{s[d \rightarrow d^*], w, o}(\text{Peter}')$,

$\{\lambda w. P(w)(\text{Peter}'): P \in \lll[\text{d-TALL}]_F\rrr^{s, f}\})$

Since $\lll[\text{d-TALL}]_F\rrr^{s, f} = \{P \in \text{Property}\} = \{\text{french}', \text{english}', \dots\}$, we can continue as follows:

... iff for some degree d^* , $\text{tall}'(w)(d^*)(\text{Peter}')$ and most members of $\{P \in \text{Property}\}$ fail to entail $\lambda w. \text{tall}'(w)(d^*)(\text{Peter}')$.

The underlined condition will normally be vacuously satisfied and hence no intensification will be felt.

Note 3: a further issue for the alternative-based analysis

A further issue should be noted. When Brow Raise occurs on a non-gradable scalar term, such as *OR*, the present line of analysis leads one to expect that the insertion of an exhaustivity operator will be forced, at least in simple cases. This may initially seem to be a good result: Schlenker et al. 2016 argue that various means of emphasis including Brow Raise can in fact serve to yield an exclusive reading of *OR* in (i)b:

(i) *Context*: Tomorrow there will be a party. The speaker and the addressee make a bet about who will show up.

a. ⁷IX-1 BET $A_{NN,a}$ OR $B_{ILL,b}$ COME.

=> if Ann and Bill come and nobody else comes, the speaker wins his bet

b. ⁷IX-1 BET $A_{NN,a}$ $\frac{\wedge}{\text{OR}}$ $B_{ILL,b}$ COME.

=> if Ann and Bill come and nobody else comes, the speaker doesn't win his bet

'I bet that Ann or Bill will come.' (ASL, 24, 07; 3 judgments; Schlenker et al. 2016)

To see why exhaustification is expected to be obligatory, let us take the set of alternatives of *A or B* to be just {*A* and *B*}. The noteworthiness requirement is that more than half of these formulas fail to entail the disjunction. This couldn't be, since *A and B* entails *A or B*. This would naturally force the insertion of an exhaustivity operator (e.g. Chierchia et al. 2012, Fox and Spector 2018). The target formula would thus become *Exh[A or B]*, with alternatives {*Exh[A and B]*}. Since *Exh[A or B]* is tantamount to an exclusive disjunction, while *Exh[A and B]* is equivalent to [*A and B*], the noteworthiness requirement will be satisfied.

While an exhaustified reading is in fact obtained in (ib), we know of no theory that predicts that focus should *force* exhaustification in case focus marking is justified in other ways. For instance, an expected reading of (i) is that I can bet that I'll pass math or physics or both: the focus on *OR* is justified by contrast and shouldn't have to be associated with an exhaustivity operator.

(i) While I wouldn't bet that I'll pass both math AND physics, I can bet that I'll pass math OR physics.

For Brow Raise, our current analysis predicts that exhaustification should be *obligatory*. This would need to be tested and the theory might have to be refined.

Appendix II. Replicating some key contrasts in LSF

In this appendix, we display a partial replication of our ASL data in LSF. Our LSF data were elicited from a native Deaf signer of Deaf, signing parents. As for ASL, we obtained acceptability judgments using the 'playback method', with repeated quantitative acceptability judgments (1-7, with 7 = best) and repeated inferential judgments (on separate days) on videos involving minimal pairs. Transcription conventions are the same as for ASL.

Because in our LSF data Brow Lowering is sometimes more natural than Brow Raise, we study both constructions in tandem (a similar study should be conducted for ASL as well). We only aim to give examples in which the contrasts we found in ASL can be replicated with repeated judgments from one consultant, *with no claim about the generality of the phenomenon across sentences, nor across consultants*. Thus we only provide an existence argument that *some* sentences can be found in which the effect found in ASL arises as well. Note that in these data (obtained before our more recent ASL examples), acceptability pertained only to the sentence as a whole (rather than to the target word), and inferential judgments were categorical (yes/no) rather than quantitative. Thus the judgments are, along several dimensions, less fine-grained data than those we collected in ASL. It should also be kept in mind that the transcription of Brow Raise and Brow Lowering on or before an expression was very clear, but that further non-manuals were added to the glosses for reasons of comparison with our ASL data, and transcribed by Lamberton. These further non-manuals are subject to much greater uncertainty than Brow Raise and Brow Lowering.

While we do not understand all our Brow Raise/Brow Lowering data in LSF, the paradigm in (54) suggests that either construction can trigger association with the focus-sensitive particle *ONLY*. In the absence of Brow Raise or Brow Lowering, as in (54)a, association appears to be with the verb: our consultant takes the signer to reject the scenario in which there is a helping relation between Marie and Pierre. In (54)b-e, by contrast, the signer is understood to reject a scenario in which someone other than Marie helps Jean. The presence of a (slight) head nod might conceivably have played a role, but as we will see Lamberton found a head nod in all our examples with any kind of emphasis below, which means that this is unlikely to explain the contrasts we find.

(54) (Acceptability of the entire sentence)

YESTERDAY IX-1 1-MEET MARIE_b PIERRE_a. ONLY IX-1 WANT ____ b-HELP-a IX-a.

a. ⁷ IX-b

⇒ I don't want someone other than Marie to help Pierre (inference not obtained)

}Λ

b. ⁷ IX-b

⇒ I don't want someone other than Marie to help Pierre [3/3 judgments]

Λ-}

c. ^{6.7} IX-b

⇒ I don't want someone other than Marie to help Pierre [3/3 judgments]

}~

d. ⁷ IX-b

⇒ I don't want someone other than Marie to help Pierre [3/3 judgments]

~}

e. ^{6.7} IX-b

⇒ I don't want someone other than Marie to help Pierre [2/3 judgments]³²

'Yesterday I met Marie and Pierre. I only want her / HER to help him.' (LSF, [57, 3753](#), 3 judgments)

³² In (54)e, in 1 out of 3 judgment tasks, the consultant inferred instead that the signer doesn't want Mary do so something other than help Pierre.

Turning to intensification, we obtained the same kinds of contrasts as in ASL in the paradigm in (55). Here *YOUNG* appears twice, but the second occurrence takes on the meaning *very young* if it co-occurs with, but not if it is preceded by, Brow Raise or Brow Lowering. In this case as well, Lambertson found head nods in all of (55)b-e, hence they are unlikely to be responsible for our contrasts. Only in case Brow Raise or Brow Lowering was on the word did we get robust intensification .

(55) (Acceptability of the entire sentence)

JEAN YOUNG. PIERRE ____ .

a.⁷ YOUNG

⇒ Pierre is younger than Jean [inference not obtained]

$\} \wedge$

b.⁷ YOUNG

⇒ Pierre is younger than Jean [4/4 judgments]

$\wedge - \}$

c.^{6,8} YOUNG³³

⇒? Pierre is younger than Jean [inference obtained in only 1/4 judgments]

$\} \sim$

d.⁷ YOUNG³⁴

⇒ Pierre is younger than Jean [4/4 judgments]

$\sim - \}$

e.⁷ YOUNG

⇒? Pierre is younger than Jean [inference obtained in only 1/4 judgments]

"Jean is young. Pierre is young / YOUNG." (LSF, [57, 3717](#), 4 judgments)

We obtained related contrasts with *SHORT* for Brow Raise, although not for Brow Lowering (for reasons we do not understand). It must be added that the inferential data in (56) are not very informative due to a Brow Raise unintentionally added on the *first* occurrence of *SHORT*.

(56) (Acceptability of the entire sentence)³⁵

PRESENTATION POSS-1 SHORT, POSS-2 ____ .

a.⁷ SHORT³⁶

⇒ your presentation is/was shorter than mine [inference not obtained]

$\} \wedge$

b.⁷ **SHORT**

⇒ your presentation is/was shorter than mine [3/3 judgments]

$\wedge - \}$

c.⁷ SHORT

⇒? your presentation is/was shorter than mine [inference not obtained]

$\} \sim$

d.⁷ SHORT

⇒? your presentation is/was shorter than mine [2/3 judgments]

$\sim - \}$

e.⁷ SHORT

⇒? your presentation is/was shorter than mine [2/3 judgments]

³³ There might be a slightly greater amplitude in this case.

³⁴ There is a slight head movement in this case.

³⁵ There was a total of 4 judgment tasks, but the crucial inferential question was insufficiently precise in the 1st judgment task and was thus modified later. For this reason, we only keep the last 3 judgment tasks. Not that for acceptability judgments, it doesn't matter whether we use all 4 judgments or just the last 3, as acceptability of the entire sentence was at ceiling in all cases (the Excel file in Supplementary Materials includes all 4 acceptability scores in this case).

³⁶ Note that in this sentence, the *first* occurrence of *SHORT* was unintentionally given a Brow Raise (on the word). This makes it hard to interpret inferential judgments for this example.

'My presentation is/was short, yours is/was short/SHORT!' (LSF, [57.3701](#), 3+1 judgments)

We make no claim about the generality of the phenomenon: some but not all additional paradigms we have explored work in the same way, which means that there is a risk of 'cherry-picking' paradigms that work as our ASL data. In addition, in some cases Brow Raise seems to be preferable to Brow Lowering, and in other cases it is the opposite. Still, it is interesting to note that there is a hope of replicating our ASL contrasts within LSF.

Appendix III. A 'bare bones' noise-based analysis

We revisit in greater detail the prospects for a noise-based analysis of our data, following in greatly simplified form the spirit of Bergen 2016.³⁷ In order to keep the discussion maximally simple, we depart from the letter of his proposal along several dimensions: (i) we focus on the case in which the speaker and addressee are entirely rational (Bergen assumes bounded rationality instead); (ii) we do not derive the benefits corresponding to different messages from the information they transmit (unlike what is standard in the Rational Speech Act model); (iii) relatedly, the agents' prior probability distribution is not taken into account by our model.

□ *Simplified case*

As in main text, we consider patterns of Brow Raise marking on *PETER TALL*, with just three types of situations, which differ from each other with respect to the Question under Discussion and/or what the speaker knows of Peter's height, as in (57):

- (57) a. **Intensificational situation:** The QUD is {PETER TALL, PETER SHORT}, and the speaker knows that Peter is very tall.
 b. **Focus situation:** The QUD is {PETER TALL, PETER SHORT}, and the speaker has no knowledge about how tall Peter is (but knows that Peter is tall).
 c. **Unmarked situation:** The QUD is {PETER TALL, PETER SHORT, PETER FRENCH}, and the speaker has no knowledge about how tall Peter is (but knows that Peter is tall).

The speaker's task is to determine whether they wish to use *TALL*, \wedge *TALL* or \wedge -*TALL*.

As argued in the main text, we posit that intensificational situations are situations of strong error because misperceiving *TALL* as *SHORT* will almost certainly lead the addressee to form incorrect beliefs in view of what the speaker knows. Misperceptions in situations of contrastive focus are less deleterious because Peter's height might in some cases qualify both as *TALL* and as *SHORT* in view of the thresholds for both predicates. Misperceptions in unmarked situations will be less serious still because when *TALL* is misperceived as *SHORT*, we are back to the preceding case (where it's likely but not certain to contradict what the speaker knows), and when *TALL* is misperceived as *FRENCH*, the information is likely to be orthogonal to what the speaker knows.

These informal considerations justify treating unmarked, contrastive and intensificational situations as situations in which misperception has a weak, medium and strong cost respectively. The benefits in (58) (already mentioned in the main text) enforce the desired ordering (in a more sophisticated model such as Bergen's, benefits would be derived from informativity). Since the literal meaning is the same for all three candidate expressions (*TALL*, \wedge *TALL* or \wedge -*TALL*), we assume that the benefit in a situation *s* only depends on whether the expression is rightly perceived. If it is, a uniform benefit $b^+(s) = 3$ is obtained, but if it is not, the benefit depends on the situation (because errors are more or less deleterious depending on the situation).

- (58) Assumptions about the benefit of rightly vs. wrongly transmitting the expression (from {*TALL*, \wedge *TALL*, \wedge -*TALL*} in different situations *s*)

Situation <i>s</i>	Benefit $b^+(s)$ if the target expression is rightly perceived	Benefit $b^-(s)$ if the target expression is wrongly perceived
Strong error	3	0
Medium error	3	1
Weak error	3	2

³⁷ We thank Leon Bergen (p.c.) for suggesting that certain parameters of cost and efficiency could derive the desired data, and Benjamin Spector (p.c.) for comments on the 'bare bones' approach developed here. Neither of them is responsible for any errors.

The speaker's strategy consists in associating one or several optimal messages to each of the three situations. Each expression e comes with a cost $c(e)$ (which does not depend on the situation): 0 for $TALL$, c_1 for $\wedge-TALL$, and c_2 for $\wedge TALL$. Each expression e also comes with a probability of misperception $p(e)$ (which is independent of the situation in which it is used): p_2 for $TALL$, p_1 for $\wedge-TALL$, and 0 for $\wedge TALL$.³⁸

(59) Messages, costs, and probabilities of corruption

Message e	Cost $c(e)$	Probability of misperception $p(e)$
$TALL$	0	p_1
\wedge $TALL$	c_1	p_2
\wedge $TALL$	c_2	0

□ *Speaker's expected utility*

In a situation s , the speaker's choice of an expression e yields an expected utility that depends on the chance that e will be corrupted, and on the benefits. It is given by the equation in (60). The expected benefit of using an expression e in situation s is just the sum of the benefit obtained if e is correctly perceived and of the benefit obtained if e is incorrectly perceived, weighted by the relevant probabilities. The third line of the equation is obtained by noting that in all cases the benefit when the message is not corrupted is $b^+(s) = 3$; by contrast, the benefit when the message is corrupted depends on the situation at hand.

(60) Speaker's expected utility when using an expression e in situation s

$$\begin{aligned}
 U(e, s) &= [\text{expected benefit of } e \text{ in } s] - [\text{cost of } e] \\
 &= [(1-p(e))*b^+(s) + p(e)*b^-(s)] - c(e) \\
 &= [3*(1-p(e)) + p(e)*b^-(s)] - c(e) \\
 &= 3 - (\mathbf{3 - b^-(s)})p(e) - c(e)
 \end{aligned}$$

Since the benefit when the message is corrupted is within $\{0, 1, 2, 3\}$, the boldfaced term will always simplify to 0, 1, 2 or 3.

The speaker's expected utility in different situations is given in (61). For clarity, we have included below the table the intended winners in each situation.

(61) Speaker's expected utility

	Cost	Perceived word	Probability of wrong/right transmission	Benefits: situations of strong/medium/weak error	Expected utility = expected benefit - cost = $3 - p(e)[3 - b^-(s)] - c(e)$		
					Strong error (intensificational situation)	Medium error (focus situation)	Weak error (unmarked situation)
$TALL$	0	wrong	p_2	$b^-(s) = 0 / 1 / 2$	$3-(3-0)p_2 =$	$3-(3-1)p_2 =$	$3-(3-2)p_2 =$
		right	$(1-p_2)$	$b^+(s) = 3$	$3-3p_2$	$3-2p_2$	$3-p_2$
\wedge $TALL$	c_1	wrong	p_1	$b^-(s) = 0 / 1 / 2$	$3-(3-0)p_1-c_1 =$	$3-(3-1)p_1-c_1 =$	$3-(3-2)p_1-c_1 =$
		right	$(1-p_1)$	$b^+(s) = 3$	$3-3p_1-c_1$	$3-2p_1-c_1$	$3-p_1-c_1$
\wedge $TALL$	c_2	right	1	$b^+(s) = 3$	$3-c_2$	$3-c_2$	$3-c_2$
Intended winners					\wedge $TALL$	\wedge $TALL$ \wedge $TALL$	$TALL$

³⁸ Our choice of indices is somewhat mnemonic because in the end we will want that $c_2 > c_1$ and $p_2 > p_1$.

□ *Appropriate values of the open parameters*

We now discuss the values of the cost (= c_1, c_2) and noise (= p_1, p_2) parameters that will yield the desired results.

We note that the expected utility for $\wedge TALL$ is constant across utility columns (it is stable at $3-c_2$), while all the other values decrease on each line as one goes from right ('weak error') to left ('strong error').³⁹ This entails that if $\wedge TALL$ is the sole winner (= sole utility-maximizing form) in one column, it is as well in columns to the left; and that if $\wedge TALL$ is non-optimal in one column, it is as well in columns to the right. The only way to distinguish our three targets is thus for $\wedge TALL$ to be the winner in the left-most column, for $TALL$ to be the winner in the right-most column, and for $\wedge TALL$ and $\wedge TALL$ to be joint winners in the intermediate column.

We now derive the conditions under which the winners are as intended.

(i) Since $\wedge TALL$ and $\wedge TALL$ are joint winners in the intermediate column, they must give rise to the same utility, which is captured by the equation in (62):

(62) **Condition for $\wedge TALL$ and $\wedge TALL$ to be tied in situations of medium error**

$$3-2p_1-c_1 = 3-c_2, \text{ i.e.}$$

$$c_2 = c_1 + 2p_1$$

This result can be interpreted as follows: in situations of medium error, $\wedge TALL$ leads to the same benefits as $\wedge TALL$ when the message is correctly transmitted, but in a proportion p_1 of the cases, $\wedge TALL$ is responsible for an error that delivers benefit 1 instead of the benefit 3 delivered by $\wedge TALL$, hence a benefit difference of 2. For $\wedge TALL$ and $\wedge TALL$ to be equally beneficial despite this difference, the cost difference between them must be $2 \cdot p_1$, as stated in (62). This is a non-trivial requirement, as it entails that the cost of $\wedge TALL$ must be greater than that of $\wedge TALL$.

We note for future reference that from (the first line of) (62), the inequalities in (63) follow as well.

$$(63) \quad 3-3p_1-c_1 < 3-c_2 (= 3-2p_1-c_1) < 3-p_1-c_1$$

(ii) In the intermediate (= 'Medium error') column, $\wedge TALL$ (and hence $\wedge TALL$, following the identical utilities derived in (i)) wins over $TALL$ and must thus yield greater utility. This is expressed in the inequality in (64).

(64) **Assuming (62), condition for $\wedge TALL$ (and thus $\wedge TALL$) to win over $TALL$ in situations of medium error**

$$3-c_2 > 3-2p_2, \text{ i.e.}$$

$$c_2 < 2p_2, \text{ i.e. (in view of (62))}$$

$$c_1 + 2p_1 < 2p_2, \text{ i.e.}$$

$$c_1 < 2(p_2-p_1)$$

(iii) In the right-most (= 'Weak error') column, $TALL$ (yielding utility $3-p_2$) should be the winner and should thus produce greater utility than $\wedge TALL$ (utility $3-c_2$) as well as $\wedge TALL$ (utility $3-p_1-c_1$). But by the right-hand side of (63), $3-c_2 < 3-p_1-c_1$, so this boils down to a requirement that the utility of $TALL$ should be greater than the larger of these two utilities, namely $3-p_1-c_1$. This is expressed in (65).

(65) **Condition for $TALL$ to win over $\wedge TALL$ and $\wedge TALL$ in situations of weak error**

$$3-p_2 > 3-p_1-c_1, \text{ i.e.}$$

$$p_2-p_1 < c_1$$

³⁹ This is of course expected since as one goes from right to left, the cost of the expression and the risk of corruption remain constant, but the effect of corruption becomes worse.

(iv) In the left-most (= 'Strong error') column, $\wedge TALL$ (yielding utility $3-c_2$) should be the winner and should thus produce greater utility than either $TALL$ (yielding utility $3-3p_2$) or $\wedge TALL$ (yielding utility $3-3p_1-c_1$). But by the left-hand side of (63), it is already guaranteed that $3-c_2 > 3-3p_1-c_1$, so we are left with the condition in (66), which requires that $\wedge TALL$ should produce greater utility than $TALL$.

(66) **Assuming (62), condition for $\wedge TALL$ to win over $TALL$ in situations of strong error** (it already follows from (62)-(63) that $\wedge TALL$ wins over $\wedge TALL$ in this case)

$$3-c_2 > 3-3p_2, \text{ i.e.}$$

$$c_2 < 3p_2, \text{ i.e. (in view of the equation in (62))}$$

$$c_1 + 2p_1 < 3p_2, \text{ i.e.}$$

$$c_1 < 3p_2 - 2p_1$$

But this result already follows on the assumption that (64) holds: $c_1 < 2(p_2-p_1) = 2p_2 - 2p_1 < 3p_2 - 2p_1$.

In the end, we are left with the conditions in (62), (64) and (65), which can be summarized as follows:

- (67) a. $c_2 = c_1 + 2p_1$
 b. $p_2-p_1 < c_1 < 2(p_2-p_1)$

These conditions are for instance satisfied by the parameters that were discussed in the main text, and are copied in (68) (multiplying or dividing all values by an arbitrary positive number would work just as well, since this wouldn't change the equations in (67)).⁴⁰

(68) Probability of misperception of $TALL$:	$p_1 = .2$
Probability of misperception of $\wedge TALL$:	$p_2 = .4$
Cost of $\wedge TALL$:	$c_1 = .3$
Cost of $\wedge TALL$:	$c_2 = c_1 + 2p_1 = .3 + .4 = .7$

From the present perspective, the table in (44) in the main text was just a 'sanity check', which showed that the desired results are obtained with these values: the 'intended winners' in (61) will in fact be selected.

This analysis just pertained to the speaker's choice of optimal forms (obtained with perfect rationality). But at the next text of the reasoning, the addressee will be aware of the association between the three kinds of situations and the three forms (corresponding to the 'intended winners' of (61)), and will thus interpret them accordingly. For instance, the addressee that sees the expression $\wedge TALL$ (with Brow Raise on the word) will know that the speaker is either in an intensificational or in a focus situation, whereas for $\wedge TALL$ (with Brow Raise before the word) the situation could only be focus-related.

□ *Question for future research*

Our analysis just offers a 'bare bones' model, whose main advantage is simplicity and concreteness. Two main questions are left for future research.

(i) How should heightened Brow Raise be analyzed? Since heightened Brow Raise before an expression plausibly involve both greater cost and greater noise-reduction efficiency than normal Brow Raise in the same position, it's relatively unsurprising that it could behave very much like normal Brow Raise on a word. Concretely: in (68), normal Brow Raise before a word, i.e. $\wedge TALL$, is both less expensive and less efficient than normal Brow Raise on a word (cost .3 vs. .7, risk of

⁴⁰ As noted by B. Spector (p.c.), the very precise values we must give in view of (67)a (and to a lesser extent (67)b) might... raise eyebrows, since one might think that speakers never have such a precise idea of the cost and especially of the risk of corruption. But as B. Spector notes, one can also interpret these numbers as the speaker's best guess in view of the diverse communicative situations they might conceivably be in.

corruption .4 vs. 0). Replacing normal Brow Raise before a word with heightened Brow Raise before the same could both increase cost and efficiency so as to eliminate the difference with (normal) Brow Raise on a word, at least in some cases.⁴¹

(ii) The 'bare bones' model developed here should be replaced with a *bona fide* Rational Speech Act model, with two key differences: (a) the utility of different forms should be derived from their informativity (and this should, in turn, give a role to the addressee's prior probability distribution); (b) perfect rationality could be replaced with bounded rationality, which might make the model more robust to deviations from the precise values posited above.

⁴¹ A related empirical question is whether heightened Brow Raise on a scalar term intensifies it more than normal Brow Raise on the same term. This is what one might expect if heightened Brow Raise is more costly and thus only worth using when noise is more deleterious, i.e. when the intended value of the scalar term is more extreme. It seems plausible to us that such gradient effects arise in spoken language. Take the following discourse. *Sam is TALL. And Robin is TALL.* With greater intensification on the second occurrence of *tall* than on the first, it seems plausible to us that one can derive an inference that Robin is taller than Sam.

Supplementary Materials: Raw Data

An Excel files with the raw quantitative scores and averages can be downloaded at the following URL (averages have normally been underlined when there was more than a 2-point difference among the averaged numbers)

<https://drive.google.com/file/d/1GBY1ro6jyXRXy1JS4SLpgpSrn3HCcvsi/view?usp=sharing>

Raw ASL and LSF data can be downloaded in .docx format at the following URL:

https://drive.google.com/file/d/1bjSTeBruztOUT12pBpSpLxaPP_r3Zfur/view?usp=sharing