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A multimodal approach to polysemy: the senses of taste and smell

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Abstract: This study explored whether co-speech gestures and linguistic markers help distinguish between the literal and figurative meanings of *taste* and *smell*, building on prior findings related to the verb *touch*. To determine whether patterns found for *touch* generalize to additional verbs, we aimed to (1) compare gestures associated with *taste* and *smell*, (2) examine the motivation behind frequent gestures associated with *taste* and *smell*, and (3) describe the relation between spoken words and the meanings of *taste* and *smell*. Gesture analysis showed that while gestures help differentiate the meanings of *touch*, they do not exhibit distinct patterns between literal and figurative meanings of *taste* and *smell*. Linguistic analysis showed that only object quantifiers were frequent when conveying literal meanings of *taste* and *smell*. Although negation and verb modifiers were key in distinguishing the meanings of *touch*, they were not commonly used with either *taste* or *smell*.

Keywords: gesture; perception; polysemy; taste; smell

1 Introduction

Polysemy, which occurs when a word has multiple related meanings, has traditionally been investigated by studying the context in which polysemous words are used (namely, by looking at the adjacent verbal elements); previous research has shown how this linguistic phenomenon can also be approached from a multimodal perspective. Bolumar Martínez et al. (2024) suggested that speakers are able to convey two different meanings of the polysemous verb *touch* by combining nonverbal (gesture) and verbal (speech) modalities. In particular, the meanings of interest for this work were the physical meaning of *touch* (i.e., literal; establishing physical contact) and the emotional meaning of *touch* (i.e., figurative; affecting

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someone in an emotional manner). This recent study discovered that when speakers express the physical meaning of this perception verb, they tend to touch an external referent such as an interlocutor or an object (*other-touch* gesture). In contrast, when speakers express its emotional meaning, they are likely to touch their own chest (*chest-touching* gesture), drawing on the Western conceptualization of the heart as the seat of emotions (Farley et al. 2021; Nummenmaa et al. 2014, 2018). Regarding verbal information, this work found that the physical meaning of *touch* often coexists with negation (e.g., *never*), while its emotional meaning usually occurs with intensifiers (e.g., *really*), showing how each of the meanings of *touch* analyzed is associated with different linguistic markers.

The present paper aims to extend the investigation of Bolumar Martínez et al. (2024) by investigating whether a multimodal approach can also provide insights into the polysemy of the perception verbs *taste* and *smell*. Given that previous research has shown that gestures and linguistic markers play a meaningful role in the interpretation of *touch*, we aim to determine whether gestures and linguistic markers (negation words, verb modifiers, and object quantifiers) also systematically accompany and differentiate between literal and figurative uses of *taste* and *smell*. If so, it would establish gesture as a modality that should be taken into consideration when examining the different meanings of perception words. In contrast, if no other perception verb benefits from a multimodal analysis, this would suggest that the scope of gesture information is not domain-based but rather of lexical nature (i.e., determined by properties of the specific word), and plays a key role exclusively with the verb *touch*.

Based on previous research (Argaman 2009; Carrillo-de-Albornoz and Plaza 2013), which demonstrated the association of linguistic markers (negation and intensifiers) with emotional attributes in language, Bolumar Martínez et al. (2024) explored the role these verbal elements had when distinguishing the physical and emotional meanings of *touch*. Although the meaning of *taste* and *smell* is most often determined by the object following the verb, linguistic markers may also be relevant in differentiating the meanings of these two perception verbs. If so, linguistic markers could function as a more 'covert' mechanism for distinguishing the meanings of perception words. Conversely, if this is not the case, it would again suggest that linguistic markers play a role exclusively with the verb *touch* and in the identification of emotional attributes in language.

Therefore, if gesture and/or linguistic markers do not function as a general meaning-distinguishing strategy across polysemous perception verbs, their relevance would appear to be verb-specific, uniquely tied to the semantics of *touch*. This would indicate that gestures do not reveal distinct conceptualizations underlying the literal and figurative meanings of all perception verbs, but rather reflect the embodied nature of *touch*, whose prototypical literal meaning (i.e., physical)

inherently involves direct physical interaction, while its emotional figurative meaning is motivated by a container metaphor (THE HEART IS A CONTAINER FOR EMOTIONS; Kövecses 1986; Lakoff and Johnson 1980). Regarding linguistic markers, this would suggest that an emotional component is necessary for these elements to contribute to meaning distinctions. Such a finding would underscore the need to consider verb-specific constraints when investigating the role of gesture and/or linguistic markers in meaning differentiation and highlight the limitations of adopting a one-size-fits-all approach to the multimodal study of polysemy.

We chose *taste* and *smell* for three different reasons. Firstly, we wanted to explore these two perception verbs because, together with *touch*, they have been traditionally considered less important than verbs such as *see* and *hear*, and, as a result, they have been less researched in linguistic studies (Fernández Jaén 2012). This aligns with the fact that the senses of taste, smell and touch have been labeled as 'lower' senses because the most primitive organisms (e.g., protozoa) only have the chemical senses of taste and smell and a basic sense of touch (Classen 1997). Secondly, these verbs (including *touch*) express highly subjective experiences due to the need for physical closeness between the perceiver and the experience perceived in order to carry out the action. This argument further contrasts these three perception verbs with those referring to the senses of vision and hearing, which are considered more objective since there is greater distance between the perceiver and the experience perceived (Fernández Jaén 2012). It is important to note, however, that most perception verbs – regardless of the associated sense – can exhibit systematic metaphorical connections with vocabulary related to the internal self and internal sensations (Sweetser 1990). Thirdly, we chose *taste* and *smell* since they are less frequently used than *see* and *hear*, and previous works (Alcaraz-Carrión et al. 2022; Pagán Cánovas et al. 2020) have shown that people tend to make more gestures with low-frequency expressions. Furthermore, selecting interconnected domains may provide insight into whether their interconnectedness is reflected in similar or contrasting gesture patterns.

When speakers use the verb *taste* to express a perceived experience, this verb typically means (1) to 'perceive the flavor of a substance by using your tongue' (e.g., *I can taste a little vanilla*). This is not the only literal meaning of the perception verb *taste*, as it can also mean (2) to 'sample the flavor of food or drink by taking it into the mouth' (e.g., *you get to taste a piece*) and (3) to 'have a specific flavor' (e.g., *a cicada would probably taste like a cricket*). While these literal meanings are similar, the primary focus varies: meaning 1 centers on the subject doing the tasting, meaning 2 on the action of tasting itself, and meaning 3 on the object whose taste is being analyzed. Beyond these literal uses, *taste* has several figurative meanings such as (4) to 'experience something' (e.g., *they can taste a little bit of what Texas is feeling*). Other figurative meanings also include the semantic extensions of the literal senses: (5) to

'perceive the property of something that is not food-related' (e.g., *generations of Afghans who […] tasted a new life*), (6) to 'sample the property of something that is not food-related' (e.g., *it's like tasting a cloud*) and (7) to 'have a specific property that is not food-related' (e.g., *they taste like a shoe*).

With regards to the verb *smell*, it also has several meanings that can focus on different aspects of a perceived experience. One of its literal meanings, which focuses on the subject or action, is (1) to 'perceive/discover a substance by using the nose' (e.g., *they smelled a foul odor*). Shifting the primary focus from the subject or action to the object reveals additional literal meanings: (2) to 'have/emit an odor' (e.g., *it smells a little like smoke*) and (3) to 'have/emit an unpleasant odor' (e.g., *we live in tents, it smells a little bit*). In relation to the figurative meanings of *smell*, they are not used to express 'olfactory information' but rather to express subjective evaluation regarding something else, such as assumptions not based on solid evidence, which can be sometimes negative. We find a variety of figurative meanings: (4) to 'detect/suspect something by means of instinct' (e.g., *I do smell a press play*), (5) to 'give indications or be suggestive of something' (e.g., *it smells a lot like pay for play*) and (6) to 'seem untrustworthy or bad' (e.g., *it smells a little fishy*).

Considering that *taste* and *smell* convey multiple figurative meanings alongside their literal uses describing acts of perception, this study explores whether speakers establish any differentiation among these meanings through co-speech gestures apart from verbal information. Expressed differently, rather than focusing solely on gestures that reflect abstract metaphorical mappings, the study also examines how gestures accompany different meanings of these verbs within the physical domain. In particular, this paper analyzes the association of the different meanings of *taste* and *smell* with linguistic information, focusing on the presence or absence of gesture and the use of specific linguistic markers. As this work aims to replicate what was done in Bolumar Martínez et al. (2024), we have established three parallel objectives: (1) to compare the co-speech gestures associated with each of the selected groups of meanings of *taste* and *smell*, (2) to determine the motivation behind potential frequent co-speech gestures associated with *taste* and *smell*, and (3) to describe the relation between the linguistic context and the literal and figurative meanings of *taste* and *smell*.

2 Methodology

2.1 Dataset and tools

The audiovisual and textual information was obtained from the NewsScape Library of International Television News, a multimodal repository of television news

managed by the UCLA and CWRU libraries(The International Distributed Little Red Hen Lab™ 2004). This database is part of the Red Hen Lab which is an international cooperative for research into multimodal communication. The dataset includes more than 600,000 h of television news programs and a 4-billion-word multilingual dataset composed by subtitles that are accurately synchronized with speech. This synchronization is crucial, as it enables researchers to view the exact moment a linguistic expression is uttered – an especially valuable feature when studying low-frequency phenomena that are difficult to elicit in laboratory settings. The communicative exchanges found in NewsScape – and in this study – are set in varied communicative situations like debates and open discussions. While the use of television recordings presents certain limitations, particularly the concern that such data may not fully represent everyday communication, the large-scale nature of the NewsScape database grants access to a wide array of communicative contexts and considerable speaker diversity (e.g., in terms of gender, ethnicity, and communicative style). In this regard, we consider the use of NewsScape to be a reasonable methodological tradeoff.

In addition to this, we employed the corpus software CQPWeb (Hardie 2012) in order to perform more complex linguistic searches. In particular, we used a subcorpus of the whole database called NewsScape English v5 (2,147,483,647 words), which gathers data and recordings from 2006 to 2017.

2.2 Linguistic searches

2.2.1 Taste

We searched for two constructions: (1) *taste a* and (2) *taste like the*/*a*/*an*. The first search was expected to be followed by a greater proportion of concrete objects since the determiner *a* can be used with countable nouns. The second search was expected to provide a 'more creative' variety of objects as it already included a simile; accordingly, we expected the proportion of figurative usages to be higher. We used the NewsScape corpus (time span selected: 1st March 2004 to 3rd October 2022) in order to obtain as many cases as possible. In this search, the number of instances in which *taste* was followed by the determiner *a* was 2,180. When *taste* was followed by the preposition *like* preceding the determiner *the*, *a* or *an*, we found 2092 instances. Although the number of matches was very similar for both searches, and despite our efforts to obtain sufficient figurative usages, literal usages of *taste* remained predominant in our final sample. Some of the concordances obtained were: *they get to taste a portion of them* (WKYC Channel 3 News at 7) and *this tastes like a shoe* (KABC The View).

2.2.2 Smell

With the verb *smell*, we followed the same approach carried out with *taste*: we searched for instances in which *smell* was followed by the determiner *a* or by the preposition *like* preceding any determiner. In this case, we decided to use the subcorpus NewsScape English v5 (2006–2017) in CQPweb so that the sample size was comparable to that of *taste*. When we searched *smell a*, we found 2,486 instances, while when *smell like* was followed by a determiner, we found 1755 instances. As with *taste*, literal usages of *smell* remained predominant in our final sample. Some of the concordances obtained were: *you could be smelling a really good quesadilla* (KNBC Access Hollywood) and *I smell like a bag of garbage* (KNBC Tonight Show with Jimmy Fallon).

2.3 Analysis

2.3.1 Data filtering

As the data stored in NewsScape originates from TV recordings, some of the cases obtained after the searches may be 'noisy'. For example, although the linguistic expression may be correctly identified, the video sometimes does not show any speaker on screen (a 'voice-over' case). This is the main reason why we needed to filter the data obtained from the different searches and discard the cases that were not suitable for our research aim. First, we deleted the cases in which no speaker appeared talking on screen. We also removed the cases which presented a tagging error (parts of speech were not correctly identified by the system), a technical issue (video/audio was not available), a text-speech mismatch, or that were repeated (the utterance appeared in a duplicate video). The last step in order to obtain the group of valid cases was to keep those cases where the speaker's hands were visible and eliminate the cases where the speaker's hands were not visible. Once the group of valid cases (i.e., clips in which speakers could be seen including their hands) was established, we further annotated the cases in which a hand gesture was made. A second coder analyzed a subset of the data to determine if there was agreement in the classification of visible hand gestures and a substantial agreement was reached: $\kappa = 0.7$ for *taste* and $\kappa = 0.77$ for *smell* (Cohen 1960).

2.3.2 Gesture analysis

We classified the visible hand gestures into those semantically related to the linguistic expression and those non-semantically related. A gesture was classified as

semantically related when it was apparently coherent with the speakers' spoken message by adding a parallel or supplementary nuance (McNeill 1992). For example, we considered the cases where speakers pointed to their mouth, when using *taste*, or their nose, when using *smell* to be semantically related. On the contrary, we classified a gesture as non-semantically related when it did not seem to be associated with the meaning of the speaker's utterance; that is, when it did not depict any semantic information associated with the spoken message. An illustration of this category are *beats* which are simple gestures that move along with the rhythm of speech (McNeill 1992).

A second coder analyzed a subset of the data to determine if there was agreement in the semantic classification of visible hand gestures. There was almost perfect agreement (κ = 0.97) for *taste* and substantial agreement (κ = 0.74) for *smell* (Cohen 1960). At this point, we eliminated non-semantically related gestures and the gestures labeled as semantically related that were produced in an 'acted' communicative situation (e.g., music performances). In the end, only the remaining spontaneous hand gestures that were classified as related to the verb were kept in the final dataset.

Once we obtained a list of the cases which contained a semantically related gesture, we annotated multiple features adopting a hybrid typology that merges distinct labels from earlier classifications (Alcaraz-Carrión 2018; Bressem 2013; Cohen 1977; Ekman and Friesen 1969; McNeill 1992). The main focus of our analysis was on the formal properties of gestures.

- *Function* of the gesture (representational,[1] emblem, other, combination)
- *Hand* used
- *Handshape* (palm, grabbing, pick, index finger, fist, other, combination)
- Gesture *axis* (lateral, vertical, sagittal, punctual,[2] other, combination, N/A)
- Gesture *direction* (rightwards, leftwards, inwards, outwards, up, down, other, combination, N/A)
- *Free* hands – i.e., was the speaker grabbing anything, such as a microphone?

1 In our initial coding, representational gestures were classified as either *deictic*, *iconic*, or *metaphoric*. However, when no meaningful patterns emerged from this distinction, we collapsed these categories into the broader term *representational* (Alibali et al. 2001; Kita et al. 2017; McNeill 1992), as the boundaries between these types can sometimes be difficult to establish. This was the case in our study, where gestural meaning is understood as a multi-layered phenomenon in which different dimensions are expressed simultaneously (Sweetser 2023).

2 Punctual gestures pinpoint a point in space rather than being produced in a particular axis (Alcaraz-Carrión 2018).

A second coder analyzed the final dataset with a substantial agreement in the identification of these formal features: κ = 0.78–0.95 for *taste* and κ = 0.63–1 for *smell* (Cohen 1960).

2.3.3 Linguistic analysis

We annotated the meaning of the verb in every valid case (where the speaker's hands were visible) by means of revising the context they were produced in. We created our meaning classification list by looking up both verbs and combining their entries in three accredited dictionaries: Cambridge, Collins and Oxford. All the authors were in charge of corroborating that the meaning classification made was accurate. The meaning options for each perception verb can be seen in Table 1.

We also annotated different aspects of the message uttered. Based on previous research (Argaman 2009; Bolumar Martínez et al. 2024; Carrillo-de-Albornoz and Plaza 2013), we decided to note down the use of different linguistic markers, as they have been shown to be frequently associated with emotional attributes in language and this might be fundamental to help identify the sense of a polysemous verb. We paid attention to the use of negation (words or particles that can turn a positive construction into a negative one; Quirk et al. 1972). In contrast with Bolumar Martínez et al. (2024), the category 'intensifiers' (words or phrases that have a heightening or lowering effect on a lexical unit; Quirk et al. 1972) was subdivided into verb modifiers and object quantifiers. We decided to differentiate them because we

Table 1: Meaning classification options for taste and smell.

	Meaning options for *taste*	**Meaning options for *smell***
Literal	1. Perceive the flavor of a substance by using the tongue	1. Perceive/discover a substance by using the nose
	2. Sample the flavor of food/drink by taking it into the mouth	2. Have/emit an odor
	3. Have a specific flavor	3. Have/emit an unpleasant odor
Figurative	4. (Have an) experience (of) something	4. Detect/suspect something by means of instinct
	5. Perceive the property of something that is not food-related	5. Give indications or be suggestive of something
	6. Sample the property of something that is not food-related	6. Seem untrustworthy or bad
	7. Have a specific property that is not food-related	
Not applicable	8. Ambiguous	7. Ambiguous
		8. Idiomatic (e.g., *smelling like a rose*)

suspected that the presence of the latter linguistic marker could potentially vary depending on the meaning expressed. Thus, we annotated whether speakers used a verb modifier (word or phrase that adds information to the meaning of the verb) or a quantifier (words such as *little*, *bit*, *lot*) before the object that followed the verb. We did not include the determiner *a*/*an* in our list of object quantifiers (even though it is a cardinal number) as it was already part of our linguistic search. The list of the negation words, verb modifiers and object quantifiers annotated can be found in the Supplementary Materials.

3 Results

3.1 Gesture frequency

3.1.1 Taste

The *taste* + *a* search gave 2,180 matches (51.03 %) and the taste + *like the*/*a*/*an* search returned 2,092 matches (48.97 %), amounting to a total of 4,272 cases (100 %). First, we discarded 1,470 cases in which the speakers were not visible (voice-over cases). From the 2,802 remaining cases, we eliminated 1,968 cases that were classified as text-speech mismatch, technical issue, tagging error or repeated. Then, we discarded 206 cases, out of the 834 cases left, in which the hands of the speaker were not visible. The remaining 628 cases were considered valid cases as we could only determine whether speakers were making a hand gesture or not when their hands were visible. Considering that this research focuses on co-speech hand gestures, we identified 376 cases containing a gesture and 252 cases where no gesture was made. In the group of co-speech gestures, we found 335 unrelated gestures and two acted gestures. Thus, only 39 related gestures were kept in the final dataset of *taste* (see Figure 1; for more data curation details see the Supplementary Materials).

The 39 semantically related hand gestures found are mostly associated with the literal meanings of *taste* (see Table 2): four gestures (10.26 %) were associated with meaning 1, five gestures (12.82 %) were associated with meaning 2 and 24 gestures (61.54 %) were associated with meaning 3. Five of the remaining gestures (12.82 %) were associated with meaning 7, the only figurative meaning present in the final dataset. The gesture left (2.56 %) was classified as ambiguous (meaning 8). In short, out of the 39 semantically related gestures, 33 (84.62 %) were made while conveying a literal meaning of *taste* and five (12.82 %) were made while expressing one of its figurative meanings.

We performed a chi-square test of independence to examine the relation between the presence and absence of semantically related gestures and the meanings

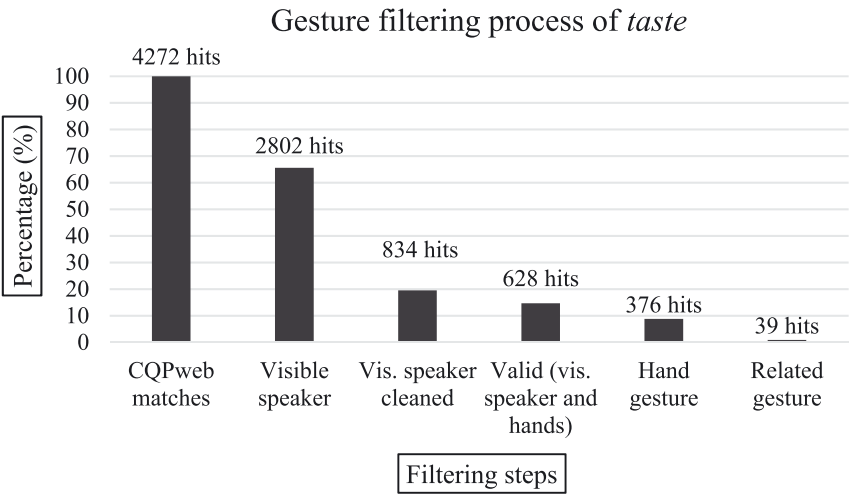

Figure 1: Gesture filtering process of *taste*.

Table 2: Distribution of the valid cases of taste (without two 'acted' gestures).

	Semantically related co-speech hand gesture	Non-semantically related co-speech hand gesture	No co-speech hand gesture	Total
Literal	33 cases (5.27 %)	276 cases (44.09 %)	195 cases (31.15 %)	504 cases (80.51 %)
Figurative	5 cases (0.80 %)	58 cases (9.27 %)	56 cases (8.95 %)	119 cases (19.01 %)
Not applicable	1 case (0.16 %)	1 case (0.16 %)	1 case (0.16 %)	3 cases (0.48 %)
Total	39 cases (6.23 %)	335 cases (53.51 %)	252 cases (40.26 %)	626 cases (100 %)

of *taste* (literal or figurative). The relation between these variables was not significant, $\chi^2(1, N = 372) = 0.4293$, $p = 0.51$. Thus, there was no difference in the distribution of semantically and non-semantically related gestures when co-occurring with the meanings of *taste*. However, it is important to note that the reduced sample size in some of the cells might limit the statistical power of the test. Fisher's exact test was not used because none of the expected cell counts fell below the conventional threshold of 5.

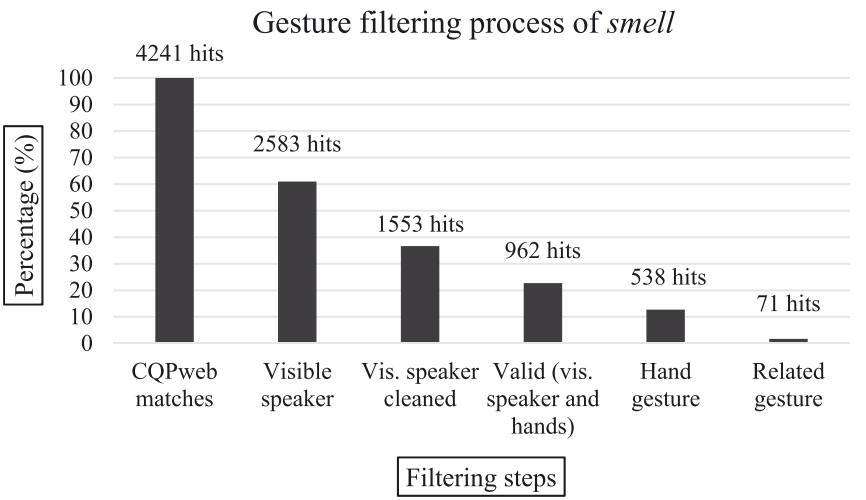

Figure 2: Gesture filtering process of *smell*.

3.1.2 Smell

The *smell* + *a* search returned 2,486 matches (58.62 %) and the *smell* + *like* + determiner search produced 1,755 matches (41.38 %), amounting to a total of 4,241 cases (100 %). First, we eliminated 1,658 cases in which the speakers were not visible (voice-over cases). From the 2,583 remaining cases, we discarded 1,030 cases that were classified as text-speech mismatch, technical issue, tagging error or repeated. After this, we removed 591 cases, out of the 1,553 cases left of 4,241, in which the hands of the speaker were not visible. The remaining 962 cases were considered valid cases as we could

Table 3: Distribution of the valid cases of smell (without 11 'acted' gestures).

	Semantically related co-speech hand gesture	**Non-semantically related co-speech hand gesture**	**No co-speech hand gesture**	**Total**
Literal	59 cases (6.20 %)	276 cases (29.02 %)	336 cases (35.33 %)	671 cases (70.56 %)
Figurative	11 cases (1.16 %)	162 cases (17.03 %)	74 cases (7.78 %)	247 cases (25.97 %)
Not applicable	1 case (0.11 %)	18 cases (1.89 %)	14 cases (1.47 %)	33 cases (3.47 %)
Total	71 cases (7.47 %)	456 cases (47.95 %)	424 cases (44.58 %)	951 cases (100 %)

only determine whether speakers were making a hand gesture or not when their hands were visible. When categorizing the group of valid cases, we identified 538 cases containing a hand gesture and 424 cases where no hand gesture was made. In the former group, we found 456 unrelated gestures and 11 acted gestures. Finally, 71 related gestures were kept in the final dataset of *smell* (see Figure 2; for more data curation details see the Supplementary Materials).

The 71 semantically related hand gestures found are mainly associated with the literal meanings of *smell* (see Table 3): 25 gestures (35.21 %) were associated with meaning 1, 33 gestures (46.48 %) were associated with meaning 2 and one gesture (1.41 %) was associated with meaning 3. Regarding the figurative meanings of *smell*, eight gestures (11.27 %) were associated with meaning 4 and three gestures (4.23 %) were associated with meaning 5. The only gesture left (1.41 %) was classified as idiomatic (meaning 8). None of the gestures in the final dataset were related to meanings 6 or 7. In brief, out of the 71 semantically related gestures, 59 (83.10 %) were made while conveying a literal meaning of *smell* and 11 (15.49 %) were made while expressing a figurative meaning.

Here, we also performed a chi-square test of independence to examine the relation between the presence and absence of semantically related gestures and the meanings of *smell* (literal or figurative). The relation between these variables was significant, $\chi^2(1, N = 508) = 12.1608$, $p < 0.001$. Therefore, the distribution of semantically and non-semantically related gestures varies when co-occurring with the meanings of *smell*. Speakers appear to be more likely to make a semantically related gesture when the sense of the verb is literal than when it is figurative.

3.2 Gesture features

3.2.1 Taste

As only 39 gestures were considered to be semantically related to *taste*, the gesture analysis of this verb is not as extensive as initially expected. Based on previous findings with the verb *touch*, we expected gestures to differ depending on whether *taste* was used literally or figuratively. Specifically, we anticipated that more action-oriented gestures, such as speakers bringing their hands to their mouths, would accompany literal uses, while more abstract gestures, such as those conveying evaluative judgments, would appear with figurative uses. Although a variety of semantically related gestures was found (e.g., mouth pointing, eating mimicry), no clear gesture patterns emerged that varied depending on the meaning of the verb. In other words, speakers did not make different gestures when conveying the literal and figurative meanings of the verb *taste*.

Figure 3: Example of a *rubbing* gesture with *taste* (https://tinyurl.com/exampletaste).

However, two formal features stood out in the final gesture dataset. The characteristic that most semantically related gestures had in common was their shape: 31 gestures were performed using a pick shape (i.e., the thumb touches the index finger and, sometimes, the rest of the fingers). Within this group of pick shape gestures, another recurring feature was observed: most speakers rubbed their fingers together (23 out of the 31 pick shape gestures). The defining aspect of these *rubbing* gestures is that the speaker's thumb touches the fingertips of one or more of the other fingers, as if about to 'make a silent snap' (typically involving the index and middle fingers; see Figure 3 for an example).

3.2.2 Smell

Among the 71 gestures that were considered to be semantically related to *smell*, we were able to observe a wide range of co-speech gestures (e.g., nose pointing, grabbing the 'smelled element'). We initially expected gestures to differ depending on whether *smell* was used literally or figuratively. As with *taste*, our original hypothesis was that literal uses would be accompanied by action-oriented gestures, such as speakers bringing their hands to their noses while sniffing, while figurative uses might evoke more abstract gestures reflecting internal states or evaluative judgments. In our limited sample, however, speakers made similar gestures when expressing the literal and figurative meanings of the verb *smell*. After observing that this hypothesis was not confirmed for *smell*, we considered the possibility that gesture might instead be used to distinguish between meanings related to odor perception versus odor emission. Despite this, no clear gesture pattern associated with the specific meanings of *smell* was identified.

Figure 4: Example of a representational (deictic) gesture with *smell* (https://tinyurl.com/examplesmell).

Most gestures were classified as representational gestures made with a palm shape. The majority of the gestures were used by speakers to indicate the area where they believed the 'smelled element' was located. As shown in Figure 4, speakers employed this deictic gesture strategy not only to indicate the location of 'physical' substances (e.g., perfume) but also to represent 'figuratively perceived' objects (e.g., *an inside job*). These results show that, when using the verb *smell*, speakers point both to concrete elements and to elements that, strictly speaking, are not physically present. When abstract deixis is used in our data, speakers seem to point to empty locations to invest them with meaning (Stukenbrock 2014). In short, the deictic gestures in our data are primarily used to anchor words to the world and to build common ground, illustrating how fundamental deixis is for speakers in referring to different types of ideas (Cooperrider and Mesh 2022). Another similar gesture strategy involved tracing the trajectory of the 'smelled element' as perceived by the speaker.

Rubbing gestures were observed in the *smell* dataset as well, although they were much less common: only two cases were identified, one of which was performed with a pick shape.

3.3 Linguistic features

3.3.1 Taste

With respect to the use of specific linguistic markers with semantically related gestures, negation (which played a significant role with *touch*; see Bolumar Martínez

Table 4: Distribution of negation words among valid cases of taste (without 'acted' gestures).

	Negation (literal)	Negation (figurative)	Total
Semantically related co-speech hand gesture	**2 (5.13 %)**	**-**	39 (100 %)
Non-semantically related co-speech hand gesture	**22 (6.57 %)**	**1 (0.30 %)**	335 (100 %)
No co-speech hand gesture	**13 (5.16 %)**	**1 (0.40 %)**	252 (100 %)
Total (valid cases)	37 (5.91 %)	2 (0.32 %)	626 (100 %)

et al. 2024) does not seem to be as relevant concerning the verb *taste*. Only two literal cases (5.13 %) in which negation was used were found:

(1) *The rye **doesn't** taste like the rye that you see in the rye bread*

(2) *This **doesn't** taste like the waxy chocolate on top of pretzels*

If we observe the use of negation among the remaining groups of valid cases, the proportion does not increase very much. Only 23 cases (6.87 %) out of the 335 non-semantically related gestures found included the use of negation. Similarly, in the group of no co-speech hand gestures there were only 14 cases (5.56 %) out of the 252 where speakers used a negation word. Overall, negation is mostly used with the literal meanings of *taste* (see Table 4).

In relation to the use of verb modifiers such as *really*, speakers do not appear to use many when making a semantically related gesture. Thus, this linguistic marker

Table 5: Distribution of verb modifiers among valid cases of taste (without 'acted' gestures).

	Vb. modifier (literal)	Vb. modifier (figurative)	Total
Semantically related co-speech hand gesture	**3 (7.69 %)**	**-**	39 (100 %)
Non-semantically related co-speech hand gesture	**28 (8.36 %)**	**3 (0.90 %)**	335 (100 %)
No co-speech hand gesture	**16 (6.35 %)**	**3 (1.19 %)**	252 (100 %)
Total (valid cases)	47 (7.51 %)	6 (0.96 %)	626 (100 %)

does not appear to be as relevant as expected. Only three literal cases (7.69 %) in which verb modifiers were used were found:

(3) *Your beverages **actually** taste a little bit better than regular ice*

(4) *I can **just** taste a hint*

(5) *It **actually** tastes a little bit like… like kidney or liver*

If we examine the use of verb modifiers among the remaining groups, the proportion shows little to no increase. Only 31 cases (9.25 %) out of the 335 non-semantically related gestures found included the use of a verb modifier. Similarly, in the group of no co-speech hand gestures, there were only 19 cases (7.54 %) out of the 252 where speakers used this type of linguistic marker. In short, verb modifiers are primarily used when speakers convey the literal meanings of *taste* (see Table 5).

The remaining linguistic marker we focus on appears to be the most relevant regarding *taste*. The use of quantifiers before the sentence object attains a higher proportion in the group of semantically related gestures; 19 literal cases (48.72 %) and just one figurative case (2.56 %) in which quantifiers were used. Some of the object quantifiers were:

(6) *They taste a **bit** stale*

(7) *It tastes a **little** grainy*

When it comes to the other groups, 109 cases (32.54 %) out of the group of 335 non-semantically related gestures included the use of an object quantifier. In the group of 252 no co-speech hand gestures, speakers used an object quantifier in 75 cases (29.76 %). Overall, the use of object quantifiers appears to be prominent when expressing the literal meanings of *taste* (see Table 6).

Table 6: Distribution of object quantifiers among valid cases of taste (without 'acted' gestures).

	Ob. quantifier (literal)	**Ob. quantifier (figurative)**	**Total**
Semantically related co-speech hand gesture	**19 (48.72 %)**	**1 (2.56 %)**	39 (100 %)
Non-semantically related co-speech hand gesture	**97 (28.96 %)**	**12 (3.58 %)**	335 (100 %)
No co-speech hand gesture	**69 (27.38 %)**	**6 (2.38 %)**	252 (100 %)
Total (valid cases)	185 (29.55 %)	19 (3.04 %)	626 (100 %)

Table 7: Distribution of negation words among valid cases of smell (without 'acted' gestures).

	Negation (literal)	Negation (figurative)	Total
Semantically related co-speech hand gesture	**-**	**-**	71 (100 %)
Non-semantically related co-speech hand gesture	**16 (3.51 %)**	**1 (0.22 %)**	456 (100 %)
No co-speech hand gesture	**10 (2.36 %)**	**2 (0.47 %)**	424 (100 %)
Total (valid cases)	26 (2.73 %)	3 (0.32 %)	951 (100 %)

3.3.2 Smell

Contrary to the findings for *touch* (Bolumar Martínez et al. 2024), the use of negation together with semantically related gestures does not appear to be relevant in relation to *smell*. In fact, no case of negation was found in the group of semantically related gestures.

If we examine the use of negation among the remaining groups, the proportion does not increase noticeably. Only 17 cases (3.73 %) out of the group of 456 non-semantically related gestures included the use of negation. In the group of 424 no co-speech hand gestures, there were only 12 cases (2.83 %) where speakers used negation. If we focus on the different meaning groups, negation is mostly used with the literal meanings of *smell* (see Table 7).

Table 8: Distribution of verb modifiers among valid cases of smell (without 'acted' gestures).

	Vb. modifier (literal)	Vb. modifier (figurative)	Total
Semantically related co-speech hand gesture	**3 (4.23 %)**	**–**	71 (100 %)
Non-semantically related co-speech hand gesture	**7 (1.54 %)**	**2 (0.44 %)**	456 (100 %)
No co-speech hand gesture	**4 (0.94 %)**	**–**	424 (100 %)
Total (valid cases)	14 (1.47 %)	2 (0.21 %)	951 (100 %)

Table 9: Distribution of object quantifiers among valid cases of smell (without 'acted' gestures).

	Ob. quantifier (literal)	Ob. quantifier (figurative)	Total
Semantically related co-speech hand gesture	**16 (22.54 %)**	**–**	71 (100 %)
Non-semantically related co-speech hand gesture	**75 (16.45 %)**	**10 (2.19 %)**	456 (100 %)
No co-speech hand gesture	**64 (15.09 %)**	**3 (0.71 %)**	424 (100 %)
Total (valid cases)	155 (16.30 %)	13 (1.37 %)	951 (100 %)

Considering the use of verb modifiers, speakers do not seem to use many when making a semantically related gesture. Thus, again this linguistic marker does not appear to be a crucial signal in pointing at different verb meanings. The final dataset only contains three literal cases (4.23 %) in which verb modifiers were used:

(8) *He **just** smells like a champion*

(9) *It **sort of** smells like the south of France over here*

(10) *If you were to crack a piece of this off, you would **actually** smell a piece of gas*

If we observe the use of verb modifiers among the remaining groups, the proportion does not increase. Only nine cases (1.97 %) out of the 456 non-semantically related gestures found included the use of a verb modifier. Out of 424 no co-speech hand gestures, there were only four cases (0.94 %) where speakers used this type of linguistic marker. Overall, verb modifiers are mostly used with the literal meanings of *smell* (see Table 8).

The remaining linguistic marker annotated once more appears to be the most important regarding *smell*. There were 16 literal cases (22.54 %) in the group of semantically related gestures in which object quantifiers were used. Some of the object quantifiers were:

(11) *We smelled a **little bit** of smoke*

(12) *She smelled a **lot** like scotch*

Out of the 456 non-semantically related gestures, 85 cases (18.64 %) included the use of a quantifier. In the group of 424 no co-speech hand gestures, speakers used a quantifier in 67 cases (15.80 %). In short, the use of object quantifiers appears to be prominent when expressing the literal meanings of *smell* (see Table 9).

Table 10: Distribution of valid cases in the analysis of touch, taste and smell (without 'acted' gestures).

	Gesture		No gesture	
	Semantically related co-speech hand gesture	**Non-semantically related co-speech hand gesture**	**No co-speech hand gesture**	**Total**
Touch	302 cases (**41.60 %**)	159 cases (**21.90 %**)	265 cases (**36.50** %)	726 cases (100 %)
	461 cases (63.50 %)			
Taste	39 cases (**6.23 %**)	335 cases (**53.51 %**)	252 cases (**40.26 %**)	626 cases (100 %)
	374 cases (59.74 %)			
Smell	71 cases (**7.47 %**)	456 cases (**47.95 %**)	424 cases (**44.58 %**)	951 cases (100 %)
	527 cases (55.42 %)			

4 Discussion

4.1 Gesture distribution in *touch*, *taste* and *smell*

The distribution of the three different groups among the valid cases is quite similar in the analysis of *taste* and *smell*, but not of *touch* (see Table 10). Although the overall distribution of gesture versus no gesture is comparable among all verbs, the difference is prominent when focusing on the distribution of the two gesture groups (semantically related and non-semantically related). While the proportion of gestures semantically related to *touch* attained 41.60 % of the valid cases (Bolumar Martínez et al. 2024), *taste* and *smell* semantically related gestures reach 6.23 % and 7.47 %, respectively.[3] Thus, a higher proportion of semantically related gestures is found co-occurring with *touch*.

This notable difference could be attributed to variations in the linguistic searches. For *touch*, personal pronouns were specifically included, enabling the identification of both literal (physical) and figurative (emotional) meanings of the verb. In contrast, the linguistic search for *taste* and *smell* aimed to capture all possible uses of the verbs without restricting the object being perceived or involved in the action. Nevertheless, it seems unlikely that these variations in the linguistic search fully account for the difference observed with *touch*.

Instead, we believe the higher proportion of semantically related gestures for *touch* is motivated by the notable difference between the meanings investigated. The

3 We checked whether the groups within the valid cases (semantically related gesture, non-semantically related gesture and no gesture) were equally distributed among the perception verbs *touch*, *taste* and *smell*. The result of the chi-square test was significant, $\chi^2(4, N = 2{,}303) = 439.1591$, p=<0.001.

meanings of *touch* were both associated with 'personal' experiences: one referred to a physical experience, which could range from positive to highly negative depending on the context, while the other referred to an emotional reaction, which could involve joy or sorrow. The need to distinguish between these contrasting meanings may explain why speakers are more inclined to use gestures when employing *touch* compared to *taste* and *smell*.

Another factor might be that the figurative meaning of *touch* can be easily conveyed through gesture. Unlike *taste* and *smell*, the figurative meaning of *touch* is frequently used by the speaker as a receiver of the action (Bolumar Martínez et al. 2024). Even though the emotional meaning of *touch* is abstract and metaphorically motivated, when speakers use the personal pronoun *me*, they can become the referent of the gesture through a 'whole-for-part' metonymic strategy – typically gesturing toward their chest. Thus, the emotional meaning of *touch* is embodied through *chest-touching* gestures, which are motivated by the container metaphor: THE HEART IS A CONTAINER FOR EMOTIONS (Kövecses 1986; Lakoff and Johnson 1980). Interestingly, the source domain of this metaphor is not related to the sense of touch. This appears to suggest that a non-perception metaphor may play a more prominent role in gesture production than a broader perception metaphor such as AFFECTING IS TOUCHING (Ibarretxe-Antuñano 1999) which encompasses both the physical and the emotional meanings of the verb *touch*.

4.2 Gesture helps distinguish the meanings of *touch*, but not *taste* or *smell*

Regarding the first objective of this paper (i.e., to compare the co-speech gestures associated with the meanings of *taste* and *smell*), we could conclude that the semantically related gestures found with literal meanings of *taste* and *smell* were also found when observing the figurative semantic extensions of these verbs. Expressed differently, the literal and figurative meanings of these verbs cannot be distinguished solely by observing the hand gestures speakers make.

Although no specific gesture patterns were exclusively tied to the different meanings of *taste* and *smell*, most semantically related gestures were somewhat iconic. Speakers often represented the perceptual action, such as moving their hands toward their mouth or simulating 'moving air' toward their nose. However, gesture referents do not appear to be as relevant to distinguish between the meanings of these two verbs as in the case of *touch*. One possible explanation is the nature of the perceptual actions these verbs convey. For *taste* and *smell*, gesture referents may be less important because these actions do not require a visually present object (even less so in figurative meanings). In the prototypical meanings of *taste* and *smell*, the

perceived element is typically an 'invisible' chemical substance in food or the surrounding air, such as bitterness or mustiness. While speakers can easily point to food they are tasting or locate the source of a smell, this strategy is less effective when referring to abstract notions in figurative meanings. This was further illustrated by the observation that, with *smell*, speakers seemed more likely to make a semantically related gesture when expressing a literal meaning.

In contrast, the verb *touch* inherently involves a physical element in the action, which can usually be pointed to or touched, when present. As discussed above, this extends to the figurative use of *touch*, where a 'whole-for-part' metonymic strategy is employed. Although with the verb *touch* we also found similar gestures in the literal and figurative meanings, it is true that we were able to distinguish different gesture patterns depending on the meaning of *touch* speakers conveyed. Here, the differences were evident when looking at the gesture referents: when the meaning was physical, they were likely to reach an external referent and when it was emotional, they were likely to touch their own chest. As previously suggested, we believe the reason behind this distinction lies in the need for speakers to differentiate between the contrasting physical (literal) and emotional (figurative) meanings of the verb *touch*.

In relation to the second objective of this work (i.e., to determine the motivation behind frequent co-speech gestures associated with *taste* and *smell*), we can only discuss the potential motivations of two frequent gestures co-occurring with *taste*: pick shape gestures and *rubbing* gestures. Despite the fact that we analyzed the most frequent semantically related gestures of *smell*, no clear pattern emerged among them.

After revising all the pick shape gestures, we observed that when this pick shape was used 'alone' (without rubbing fingers), it appeared to be mostly related to the action of taking something and bringing it towards one's mouth. Thus, we believe that the motivation behind pick shape gestures is their iconic resemblance to the handshape people use when grabbing food.

It should be noted that although *rubbing* gestures were frequently used when uttering the verb *taste*, they also appeared when speakers used *smell*. At first, we believed that the *rubbing* gesture was somewhat related to the domain of TASTE, as speakers appeared to raise their hands to make the gesture more visible, with some even bringing their hands closer to their mouths. For this reason, the *rubbing* gestures observed were considered intentionally communicative and semantically related to *taste*. However, it seems more likely that *rubbing* gestures are particularly associated with the difficulty of describing an experience perceived. After analyzing the speakers' utterances, we noticed that these gestures were often produced when speakers struggled to describe the flavor of a food product. Elements indicating vacillation included interjections, repetitions and pauses. Taking this into

consideration, *rubbing* gestures seem to be used when speakers find it challenging to articulate an accurate descriptor for their spoken message.

In order to explore the potential motivations of the gestures co-occurring with the verb *smell*, we examined whether there were any tendencies in the direction of gestures that distinguished the perception of smell from the emission of smell. Most gestures were directed inwards, even when the meaning of *smell* expressed the notion of emission. However, we ultimately discarded this analysis due to the high variability of gestures in the final dataset, which made consistent patterns difficult to identify. Although no motivation could be analyzed in detail, we were able to observe how specific semantic components of *smell* are represented through co-speech gestures.

If we compare the motivation behind the most frequent gesture made with *touch* (the *chest-touching* gesture) with the motivations behind pick shape and *rubbing* gestures, it is clear that the sources of these motivations are very different. While *chest-touching* gestures are believed by Bolumar Martínez et al. (2024) to be based on the conceptual metaphor THE HEART IS A CONTAINER FOR EMOTIONS (Kövecses 1986; Lakoff and Johnson 1980), the motivation behind pick shape gestures seems to be primarily based on an iconic representation of the action of tasting. The exact motivation behind *rubbing* gestures cannot be determined, as in this study it is unclear whether this peculiar gesture represents semantic features of *taste* and/or *smell* or if it serves as a discourse-related element used when speakers struggle to find an accurate descriptor.

4.3 Linguistic markers help distinguish the meanings of *touch*, *taste* and *smell*

Concerning the third objective of this research (i.e., to describe the relation between the linguistic context and the literal and figurative meanings of *taste* and *smell*), only the use of object quantifiers attained a substantial proportion in both verbs. Although we also examined the use of negation and verb modifiers, these two types of linguistic markers were not commonly used in the valid cases for either *taste* or *smell*. It should be noted that, due to this and the extremely low proportion of cases where speakers expressed figurative meanings of *taste* and *smell*, no model could be calculated.

With regards to object quantifiers, their use appears to be more prominent when expressing the literal meanings of *taste* and *smell*. However, no relation between their use and the particular meanings of the verbs could be identified. The association of object quantifiers with the literal meanings of both verbs should be interpreted with caution due to the low frequency of figurative meanings found in this study.

The use of object quantifiers with *taste* and *smell* suggests that both the sense of taste and the sense of smell are conceptualized along a gradable scale. This means that the perceived substance, flavor or odor, might change depending on the perceiving person and environmental factors, such as the distance to the substance source or the location where the experience occurs. In short, the subjectivity and the 'chemical nature' of the senses of taste and smell are reflected in the high proportion of object quantifiers. Furthermore, speakers often describe flavors and odors saying that a substance *tastes*/*smells a bit*/*a little*/*a lot*/*very* + adjective. This illustrates how, through tasting or smelling, speakers can detect different components and even determine the intensity of the substance perceived. For example, the sentence *it's milk that tastes a little sour* conveys the idea that, even though milk is expected to be slightly sweet, in this case, the sour flavor exceeds the expected level of perceived sweetness.

Unlike *taste* and *smell*, a very low proportion of object quantifiers was used with the literal (physical) meaning of *touch*. The analysis of *touch* showed that speakers used intensifiers (verb modifiers and object quantifiers) primarily when expressing the figurative (emotional) meaning of *touch*. It should be noted that regarding the distribution of intensifiers found in the analysis of *touch*, most were verb modifiers.

The use of verb modifiers and object quantifiers with *touch*, *taste* and *smell* reveals how the same experience can be perceived with different degrees of intensity. Although the frequency of the linguistic markers used with *touch* differs in comparison with the other two perception verbs, it still shows that the emotional (figurative) meaning of *touch* is also perceived along a gradable scale, likely because emotions cannot be controlled by an external being (Bolumar Martínez et al. 2024). Contrary to the analyses of *taste* and *smell* which show that the 'gradable conceptualization' is primarily present in literal meanings.

Overall, the distribution of object quantifiers highlighted the meanings that were conceptualized along a gradable scale. In the case of *taste* and *smell*, this linguistic marker was predominantly used with their literal meanings. The analysis of the verb *touch* revealed that object quantifiers were mainly used when speakers conveyed the figurative (emotional) meaning of the verb.

5 Conclusions

This paper explored whether the meanings of the polysemous verbs *taste* and *smell* could be differentiated through co-speech hand gestures and linguistic markers, extending the findings of Bolumar Martínez et al. (2024) for the verb *touch*. In short, we investigated whether the patterns observed for *touch* generalize to additional perception verbs or if such patterns are verb-specific.

The gesture analysis reveals that, while gesture plays a relevant role in differentiating the meanings of *touch*, it does not exhibit different patterns between the literal and figurative meanings of *taste* and *smell*. Although two gestures, the pick shape gesture and the *rubbing* gesture, often co-occurred with *taste*, they did not systematically correspond to specific meanings.

Considering that only object quantifiers were frequently associated with the literal meanings of both *taste* and *smell*, the analysis of linguistic markers indicates that these verbal features provide more discriminating information regarding the meanings of *touch*. Although the use of negation and verb modifiers did not show a meaningful distribution across meanings for either verb in this study, the frequent use of object quantifiers aligns with the conceptualization of the senses of taste and smell as gradable, where the perceived intensity of flavors and odors can vary depending on individual and external factors.

The main limitation of this work is the low frequency of semantically related gestures observed when speakers convey figurative meanings of *taste* and *smell*, making it difficult to draw strong conclusions about such gestures. However, this could also be considered a contribution, as the use of a large multimodal dataset allowed the identification of low-frequency gestures that might have otherwise been missed, such as the *rubbing* gesture.

Although a big data approach was used to collect gesture data, further investigation is needed to confirm our hypothesis that speakers use *rubbing* gestures when they experience difficulty finding verbal descriptors for experiences perceived. Additionally, future research could explore different perception verbs with well-established figurative uses, such as *see* and *hear*, to better identify which communicative modalities might help distinguish the meanings of a polysemous word.

Overall, while the findings of this paper suggest that gesture may not play a primary role in distinguishing meanings of *taste* and *smell*, the prominence of object quantifiers when expressing literal meanings of both verbs could be considered a shared meaning-differentiating pattern. These results underscore the value of multimodal data in polysemy research, as they show how the role of co-speech gestures and linguistic markers varies across different perception verbs.

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Data availability

Data and supplementary materials are publicly available in the following link: https://osf.io/jna28/overview.

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