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RUNNING HEAD: Gesture and pain sensation

Handling pain: The semantic interplay of speech and co-speech hand gestures in the description of pain sensations

Samantha Rowbotham<sup>1</sup>, Judith Holler<sup>1,2</sup>, Donna Lloyd<sup>1,3</sup> and Alison Wearden<sup>1</sup>

<sup>1</sup> School of Psychological Sciences, Coupland Building, University of Manchester, Oxford Road, Manchester, M13 9PL, UK

<sup>2</sup> Max Planck Institute for Psycholinguistics, Wundtlaan 1, 6525 XD, Nijmegen, The Netherlands

<sup>3</sup> Institute of Psychological Sciences, University of Leeds, Leeds LS2 9JT, UK

SUBMISSION TO: Speech Communication: Special Issue on Gesture and Speech in Interaction

CORRESPONDENCE TO: Samantha Rowbotham. School of Psychological Sciences, University of Manchester, Oxford Road, M13 9PL. Telephone: 0161 306 1750. Fax: 0161 275 2588

Email: [Samantha.Rowbotham@manchester.ac.uk](mailto:Samantha.Rowbotham@manchester.ac.uk).

**Abstract**

Pain is a private and subjective experience about which effective communication is vital, particularly in medical settings. Speakers often represent information about pain sensation in both speech and co-speech hand gestures simultaneously, but it is not known whether gestures merely replicate spoken information or complement it in some way. We examined the representational contribution of gestures in a range of consecutive analyses. Firstly, we found that 78% of speech units containing pain sensation were accompanied by gestures, with 53% of these gestures representing pain sensation. Secondly, in 43% of these instances, gestures represented pain sensation information that was not contained in speech, contributing additional, complementary information to the pain sensation message. Finally, when applying a specificity analysis, we found that in contrast with research in different domains of talk, gestures did not make the pain sensation information in speech more specific. Rather, they complemented the verbal pain message by representing different aspects of pain sensation, contributing to a fuller representation of pain sensation than speech alone. These findings highlight the importance of gestures in communicating about pain sensation and suggest that this modality provides additional information to supplement and clarify the often ambiguous verbal pain message.

Keywords: co-speech gesture; gesture-speech redundancy; pain communication; pain sensation; semantic interplay of gesture and speech

**Highlights**

- Pain sensation is often difficult to communicate verbally
- Examines semantic interplay of speech and gesture in representing pain sensation
- Gestures complement speech by representing unique information about sensation
- Gestures sometimes specify spoken information about pain sensation
- We need to attend to gestures to obtain a fuller understanding of pain sensation

**1. Introduction****1.1. Co speech hand gestures**

It is well established that co-speech gestures play an important role in face-to-face communication and interact with speech to communicate the intended message of the speaker [1-3]. Co-speech gestures are thought to emerge from the same underlying mental representation as speech, thus constituting an integral component of human language [4, 5]. They can be defined as the spontaneously produced movements of the hands, arms and other body parts that are closely linked with speech in a temporal fashion and can serve both semantic and pragmatic functions within the discourse [4]. To date, a plethora of research has explored the semantic interplay between gesture and speech in concrete domains of talk (such as spatial descriptions and cartoon narratives), revealing that gestures frequently complement the information contained in speech. However, little is known about how the two modalities semantically interact in the communication of more abstract, perceptual domains, such as pain. Given the importance of effective pain communication within both medical and everyday settings, and the difficulties that pain sufferers face in verbalising their pain experience, we sought to explore the semantic interplay between co-speech gestures (henceforth ‘gesture’ for brevity) and speech with a focus on whether (and in what ways) gestures can complement the verbal pain message.

‘Representational’ (or topic) gestures [6-8] are closely linked to the semantic content of speech and can be used to depict or refer to a range of entities within the real or imagined environment of the speaker [4]. For example, a speaker may use a pointing gesture to indicate the location of an object or use a gesture in which they move their hand in a wide circular motion at hip level to depict the size, shape and height of a table. These gestures allow the speaker to visibly express information in a way that is often not permitted by speech, providing an additional window into the speaker’s mind [4].

A number of studies have investigated the use of representational gestures (primarily ‘iconic’ gestures, i.e. those which depict concrete events, objects, and entities [4]), with findings indicating that speakers distribute information across gesture and speech. Moreover, these analyses have shown that while the information in gesture and speech often overlaps, gestures can also complement speech by providing additional information that is not contained in speech at all [1, 2, 4, 9-18]. Further, through providing additional information gestures have been found to disambiguate spoken information, make the verbal meaning more precise, add specificity to the information provided by speech, and exhibit information that is difficult to convey by verbal means alone [4, 15, 16, 19-22]. Finally, it has been shown that the information speakers encode in their gestures is meaningful to recipients and that in trying to understand speakers’ messages, recipients benefit significantly from receiving the additional information contained in gesture [17, 23-28]. However, all of this work has focused on speakers’ use of speech and gesture in the communication of rather concrete information, typically cartoon stories or descriptions of spatial patterns and layouts (such as line drawings, dot configurations, shapes and patterns of items of clothing, apartment floor plans, furniture arrangements and so forth). What we still know very little about is how information from speech and gestures combines when communicating about more abstract and perceptual concepts, such as the subjective experience of pain.

## 1.2. Pain Communication

Pain is a sensation with which we are all familiar and is one of the most frequently reported symptoms in medical consultations [29]. Despite this, the communication of pain presents a challenge within medical and everyday interactions because it is a private, subjective experience, directly accessible only to the sufferer. Pain often occurs in the absence of visible signs of injury (such as a wound), and even when visible signs are present they do not necessarily indicate what the pain feels like to the sufferer and degree of tissue damage does not directly correlate with self-reported pain intensity [30]. Thus, to make their pain known and receive understanding, treatment and support, sufferers must communicate the characteristics of their pain experience to others.

Although verbal communication about pain is seen as the ‘gold standard’ within medical settings [31-33], there are a number of problems with a reliance on this modality alone. First, there is no generally established vocabulary for describing non-extrinsic phenomena or sensations such as pain [34, 35] and patients frequently report difficulties in finding the words to adequately convey their experience to others [36-38]; “what pain achieves it achieves in part through its unsharability...its resistance to language” [39, p.4]. Further, the language evoked to describe pain, particularly its sensory or qualitative dimension, is primarily based on analogies relating to external actions or stimuli, e.g. “it is as if someone is stabbing me” [36, 40]. As such, these descriptions may not map directly onto the internal sensation, for example, while a ‘stabbing’ pain may have certain qualities associated with the sensation of being stabbed, it is unlikely that it would directly resemble the experience. Further, this description does not distinguish whether the ‘stabbing’ sensation is like that of receiving shallow punctures to the skin or of something sharp being driven deep into the body, or that occurs rapidly or more slowly, with more or less force, or with different degrees of repetitiveness.

This leads to the second key difficulty in verbal pain communication, the potential for misunderstanding the experience. It is difficult to unequivocally name sensations within a shared public language because we cannot point to our pain and say “that is a stabbing pain” in the way that we can with things in the external world (e.g., “this is a table” or “that is a chair”). Thus, we cannot be sure that the way we intend for ‘stabbing’ to be understood matches the understanding of the recipient. This is supported by Salovey et al.’s [41] finding that participants named on average ten different pain experiences when asked to indicate which types of pain they thought were best described by a series of adjectives. Treasure [42] notes that the verbal expression of pain is even more problematic when communicating about unusual pains, such as those originating from the inner organs (e.g. the heart or gall bladder) or associated with specific pain conditions (e.g. endometriosis), due to the lack of a shared experience to draw on when communicating with others. Taken together, this suggests that not only do pain sufferers struggle to verbalise their experience but that the resulting verbalisation is subject to misunderstanding by recipients.

### 1.3. Co-speech gestures in pain communication

Given the difficulties of adequately expressing pain through the verbal modality, and the large body of work highlighting the role of gestures in communicating semantic information about a range of concrete topics, it may be that gestures also represent important information when communicating about pain. This is an area which, to date, has not been well explored. However, initial qualitative research has revealed that speakers do indeed use both speech and gestures to convey information about pain [43, 44]. In particular, speakers use gestures to indicate the location of the pain, to mime actions that cause pain, and to convey information about pain sensation, for example by rapidly striking the fingertips against the thumb to demonstrate a ‘tingling’ sensation [44], or gesturing to indicate the sensation of a band tightening around the front of the head when describing a headache [43]. However, as these

studies focused on a small number of individual gestures and the accompanying speech, they tell us little about the overall distribution of pain information across gesture and speech or the semantic interplay between the two modalities.

A recent quantitative study [45] investigated the distribution of pain information across the two modalities using a ‘semantic feature analysis’ [9, 10, 16, 17] in which speech and gestures were scored according to whether they contained information about eight different aspects of the pain experience (location, size, quality, intensity, duration, cause, effects and awareness). This analysis revealed that 41% of information about the pain experience was represented uniquely in gestures, with information about the location and size of the pain most often represented in gesture alone. Further, 35% of information was represented simultaneously in speech and gestures, with information about pain sensation (referred to as ‘quality’) more often represented in both modalities together than either modality alone. The finding that pain sensation was most often represented in both modalities together supports the qualitative findings [43, 44] that references to pain sensation in speech are sometimes accompanied by a gesture also containing this information.

A recent qualitative exploration of the interplay between speech and gesture when both modalities represent pain sensation [46] revealed that gestures serve two key functions. Firstly, gestures can represent information about different aspects of pain sensation to those contained in speech, for example by depicting the pain as a repetitive hammering sensation while describing it as “something really heavy pushing down”. Secondly, gestures can provide a more detailed or specific representation of sensation than that contained in speech, for example by depicting heavy downward pressure by forcibly pushing one hand down under the other, while the accompanying speech only represents the pain as “pressure” [46. pp. 21-22, emphasis added]. However, as a qualitative study this does not provide us with



detailed information on how frequently gesture performs these functions in the representation of pain sensation.

An appreciation of the specific interplay between speech and gestures in the representation of pain sensation is important because, while sensation is a key feature of the pain experience and one that health professionals must attempt to understand in order to provide adequate treatment and support [47, 48], it also appears to be an aspect of the pain experience that sufferers find particularly difficult to convey to others. Thus if gestures are able to provide a fuller or more specific representation of pain sensation then this has important implications for the understanding and treatment of pain. Therefore, we aimed to extend the findings of previous research by examining: 1) whether (and how often) gestures contain additional (unique) information about pain sensation that is not contained in the accompanying speech, and 2) whether (and how often) gestures provide a more specific representation of pain sensation than the accompanying speech. A consideration of these questions will provide a more detailed understanding of the interplay between speech and gestures when both modalities contain information about the same category of information (sensation).

Concerning the question of whether gestures contain additional information about pain sensation that is not contained in the accompanying speech, a 'redundancy analysis' [13-16] will be performed. Given the difficulties associated with verbal pain communication, we predict that gestures will indeed contribute additional information about pain sensation that is not contained in speech, thus serving to extend the verbal expression and provide a fuller representation of pain sensation.

To address the question of whether gestures provide a more specific representation of pain sensation than speech we will use a dichotomous coding scheme based on Gerwing and Allison [16] to consider whether gestures and speech represent pain sensation in a specific or

general manner. In line with past findings using similar coding schemes to analyse the contribution of gestures in the concrete domain (and given the difficulties of verbal pain communication), we predict that gestures will more often contain specific information about pain sensation while speech will more often represent pain sensation in a general manner.

## **2. Method**

### **2.1. Participants**

Thirty-one undergraduate psychology students (24 female; 29 right-handed according to Edinburgh Handedness Inventory [49]) aged between 18 and 22 years (Mean age = 19.26 years) took part in return for course credit. All participants were native English speakers and none had taken part in a similar study or had suffered from known language impairment. Data from three participants were excluded: two due to problems with recording equipment and one due to a failure to follow the study instructions. Thus, the analysis was based on data from 28 participants (23 female; 26 right-handed, Mean age = 19.14 years).

### **2.2. Materials**

#### **2.2.1. Experimental pain apparatus**

An experimental pain apparatus was used to elicit the pain experience about which participants would later be interviewed. We chose this type of pain experience over more ‘natural’ pain for ease and consistency of analysis, and to control for the possibility that different types of pain experiences may lead to individual differences in communication because of differences in pain duration, intensity and location, and emotions or anxiety about pain. The pain elicitation involved pressure being applied to the fingernail bed using a pneumatic force controller (Dancer Design UK) with a compressed air cylinder and a plastic probe with a 1cm diameter. Turning the control dial clockwise lowered the probe and increased the pressure, and turning the dial anticlockwise moved the probe upwards and

released the pressure. The apparatus was fitted with an emergency release button that immediately expelled all air from the machine and lifted the probe, terminating the pressure.

### 2.2.2. Numerical Rating Scale (NRS)

During pain elicitation, participants' subjective ratings were used as the determinants of pain intensity. Participants were given an 11-point NRS (0 to 10) containing three verbal anchors: 'no pain' (0), 'moderate pain' (5), and 'worst pain' (10) with instructions to increase the pressure until the pain reached the specified intensity (see 2.3. Procedure).

### 2.3. Procedure

Ethical approval was obtained from the School of Psychological Sciences Research Ethics Committee at the University of Manchester (Ethics code: 154/07P). Participants were informed that the study was concerned with how people communicate about pain and that they would be videotaped throughout. Participants received an instruction sheet and the researcher (SR) showed the participant how to operate the apparatus.<sup>1</sup> The researcher ensured that participants understood the procedure and that they were free to use the emergency release button at any time. As participants were to be interviewed about the pain experience immediately following the pain elicitation they were asked not to discuss the experience until this point and any attempts to describe the pain during the procedure were discouraged.

Participants placed the middle finger of their non-dominant hand on the platform below the probe and aligned their fingernail bed with the underside of the probe, which the researcher then manually lowered until it rested against the fingernail bed. Once the participant was ready to begin, they were instructed to gradually increase the pressure and to stop and inform the researcher when the pain had reached the specified intensity on the NRS

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<sup>1</sup> Although the researcher (SR) explained how to operate the apparatus, this did not involve the researcher using the apparatus on her own finger as this would have created a shared pain experience between the researcher and participant, leading to potential confounds on the communication process [49-51]. Instead, the explanation focused on how to operate the dials to move the probe and how to use the emergency stop button.

(‘5’ for the practice trial, ‘7’ for the main trial<sup>2</sup>; see 2.2.2. Materials). In the main trial participants were asked to keep the pressure at this level for thirty seconds before releasing the pressure.<sup>3</sup> Participants were encouraged to keep hold of the pressure release button during the pressure application so that they could terminate the pressure quickly and easily if necessary. The mean level of pressure applied by participants in the main trial was 0.53 bar (SD = 0.08; Range = 0.40 to 0.75).

Following the pain elicitation, participants took part in a semi-structured interview about the pain. The questions were adapted from previous work [45] and aimed to capture various aspects of the experience, including sensation, location and intensity of the pain as well as dimensions such as pain-related emotions and perceived control. Prior to the interview the researcher placed the pain apparatus on the floor and covered it up to encourage participants to focus on the sensation of the pain, rather than on the apparatus that caused it. During the interview, the participant and researcher sat opposite each other across a low coffee table at a comfortable conversational distance. The mean interview length was 4 minutes (Range = 2 min 38 sec – 6 min 42 sec). The entire procedure was video-recorded split-screen using wall-mounted cameras to give frontal views of the participant and researcher. At the end of the study, participants were reminded of their freedom to withdraw. All participants allowed their data to remain in the study and when questioned, no participants indicated that they were aware that the purpose of the study was to investigate the use of gestures.

#### 2.4. Analysis

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<sup>2</sup> The intensity level of ‘7’ was chosen following initial piloting to establish a point at which participants identified the sensation as ‘painful’ without being unbearable. This was important as participants were required to maintain the pressure for 30 seconds once pain had reached the level of ‘7’. When higher intensity levels were used participants were reluctant to maintain the pressure for this duration. When asked to use levels below ‘7’ the sensation was not necessarily considered painful by participants.

<sup>3</sup> Participants were informed at the beginning of the study that they would be asked to keep the pressure applied for 30 seconds but that they were free to terminate this pressure early if necessary. Participants were also made aware at the beginning of the study that course credit was not linked to completing the experiment and that they could abandon and would still receive the study credits.

The analysis proceeded in three stages 1) speech transcription and gesture identification followed by identification of pain sensation in speech and gestures, 2) analysis of gesture-speech redundancy in representing pain sensation (i.e. whether gestures added unique information about pain sensation), and 3) analysis of the specificity of information about pain sensation in speech and gesture (i.e., whether gestures made the sensation information contained in speech more precise).

#### 2.4.1. Identification of pain sensation in speech and gesture

##### 2.4.1.1. Speech

Interviews were transcribed verbatim and segmented according to ideation units [50], which are segments of speech (or text) which express one semantic idea. Unlike clausal units, ideation units allow segmentation based on the semantic content of speech so that if the same idea is elaborated across clauses it is not split into segments according to grammatical structure but is kept as a whole unit of meaning.

All ideation units containing information about pain sensation were identified. Pain sensation was defined as the quality or character of the pain, how the pain feels or what it is like, for example, “it was definitely more sharp, more of a cutting sort of pain, like it felt like it was cutting into me”. To ensure reliability a second researcher trained in qualitative analysis of speech data identified all speech units containing information about pain sensation in six randomly selected transcripts (equating to 21% of data). Cohen’s Kappa was  $k = .83$  (92% agreement), suggesting a high level of agreement between the two researchers [51].

##### 2.4.1.2. Gesture

Following the identification of spoken ideation units containing information about pain sensation, all representational gestures (see Introduction) accompanying these speech units

were identified.<sup>4</sup> Manual movements, such as rubbing one's ear or playing with a pencil (i.e., 'self-adapters' and 'object-adapters' [52]), do not represent semantic information and were excluded from the analysis. During the interview, participants frequently touched or held the finger to which pressure had been applied; thus, to prevent overestimation of the contribution of gestures, these cases were considered to be self-adapters unless it was clear that the movement was gestural in nature [i.e., if it was performed in central gesture space, had a clear stroke phase, and was clearly linked with speech in a temporal and semantic manner; 4)]<sup>5</sup>.

Once all gestures were identified, a decision was made as to whether any information about pain sensation was contained in the gestures. As above, pain sensation was defined as the character or quality of the pain sensation, how the pain feels or what it is like. For example, a gesture in which the palm of the right hand is brought down onto the back of the left hand to depict the pain as having a pressing or pushing character was considered to contain information about pain sensation. In total, 222 speech units were identified as containing information about pain sensation. To ensure reliability, a second researcher trained in gesture analysis identified all gestures accompanying speech units containing pain sensation in six randomly selected video files (equating to 21% of data). Cohen's Kappa was  $k = .84$  (95% agreement), indicating a high level of agreement between the two researchers [51]. The same researcher then made a decision as to whether each of the gestures contained information about pain sensation or not. Cohen's Kappa resulted in  $k = .72$  (91% agreement), indicating a substantial level of agreement [51].

#### 2.4.2. Redundancy/Complementarity of sensation information in gestures

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<sup>4</sup> Because the focus was on the representation of pain sensation in both modalities together any gestures occurring with speech that did not pertain to pain sensation were not considered within the present analysis.

<sup>5</sup> To address the concern that people may perform manual gestures at a higher rate when talking about pain in the hand compared to elsewhere in the body, we considered the gesture rates in the present data compared with those obtained by Rowbotham et al. (2012) when participants described naturally occurring pain in various bodily locations. This revealed that there were no significant differences between overall and representational gesture rates in the two studies ( $p$ -values  $> .05$ ).

To address the question of whether gestures contained any additional information about pain sensation that was not contained in speech, we conducted a ‘redundancy analysis’ [13-16]. Within this analysis gestures were coded as ‘redundant’ if they only contained information about pain sensation that was already represented in the accompanying speech (i.e. they replicated the information in speech and did not contain any additional information about pain sensation; see Figure 1(d) for an example). Conversely, if the gesture contained any additional information about pain sensation that was not contained in speech then it was considered ‘complementary’ (see Figure 1(a, b, c) for examples).

All gestures that contained information about pain sensation and accompanied a speech unit containing information about pain sensation ( $n = 117$ ) were included in the analysis<sup>6</sup>. Where there were multiple gestures containing information about pain sensation accompanying one speech unit these were viewed together as constituting a single ‘gestural ideation unit’ (in much the same way that one spoken ideation unit may contain multiple clauses representing the same idea) and their overall contribution was considered (i.e. if any of the gestures accompanying a speech unit added information about pain sensation then the gesture unit as a whole was considered to be complementary with respect to speech).

In order to make the redundancy judgements as ‘objective’ as possible, for each gesture-speech unit the researcher listed all the ‘features’ of pain sensation contained in each modality independently (e.g. throbbing, stabbing, pushing). Gestures were only considered ‘complementary’ if the list of ‘sensation features’ for gesture contained one or more features that had not been listed for speech. To further limit the subjectivity of coding decisions, members of the research team engaged in extensive discussions about the sensation information contained in the gestures from our corpus.

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<sup>6</sup> The number  $n=117$  is a subset of the ( $n=222$ ) speech units containing information about pain sensation and refers to the number of speech units containing information about pain sensation that were accompanied by gesture(s) also containing information about pain sensation.

A second independent researcher with expertise in gesture research coded the gestures in six randomly selected videos (containing 27 gestures = 23%) for redundancy. Cohen's Kappa was  $k = .61$  (81% agreement), indicating substantial agreement between researchers [51]. Applying a correction for unequal base rates this can be interpreted as reflecting 89% accuracy [53].

#### 2.4.3. Specificity of information in gesture and speech

To address the question of whether gestures provide more specific information about pain sensation than is contained in speech, we used a dichotomous coding scheme in which information in speech and the accompanying gestures was scored as being general or specific [16], concerning the depiction of pain sensation<sup>7</sup>. All speech units containing pain sensation (regardless of whether they were accompanied by a gesture;  $n = 222$ ) and all gestures representing pain sensation that accompanied a speech unit also representing pain sensation ( $n = 117$ ) were included in the specificity analysis. Each speech unit and each gesture unit was (independently) assigned to one of the following categories for the representation of pain sensation:

**Specific:** Information about the aspect of pain sensation that is depicted is represented in a detailed and specific manner, such that the speech or gesture conveys a clear picture of the sensation, with no real ambiguity or need to add anything to make the sensation clear. For example, the phrase, "it's like when you trap your finger in the door", indicates in an unambiguous manner what the sensation is like by giving a description that refers to a concrete event. Similarly, a gesture in which the heel of the right hand is brought down rapidly and forcefully onto the fingertips of the left hand clearly depicts the nature of the sensation by reference to an action. Although there are necessarily differences in the way in

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<sup>7</sup> We initially employed a tripartite scheme with the categories not specific, somewhat specific, and specific but the analysis revealed that 'not specific' representations were very rare in both gesture and speech. As such, we collapsed the not-specific and somewhat specific categories into a 'general' category in line with previous work [16], thus providing the binary coding scheme described here



which gestures and speech represent information (visibly versus linguistically), the key criteria for either modality to be coded as containing specific information was that they represented the information in such a way that it was easy to infer the nature of the sensation without the need for further clarification. See Figure 1 for more examples of specific speech and gestures.

General: Information about pain sensation is represented in such a way that although the speech or gesture gives some idea of the sensation, more information is needed to specify this more fully or the representation is ambiguous to some extent. For example, the speech, “it felt like, you could feel the pressure”, conveys the idea that the sensation was one of pressure but does not provide information on the type of pressure (e.g., external pressure caused by something pressing on the finger, or internal pressure, such as the feeling of swelling from the inside<sup>8</sup>), such that more detail is needed to clarify the type of pressure pain. Similarly a gesture in which the right hand is suspended, palm downwards above the fingers of the left hand and moved down and back up repeatedly without touching the left hand conveys the idea of a repetitive downwards pressure but does not indicate the force with which this pressure is applied, meaning that more detail is needed to clarify the nature of the sensation. See Figure 1 for more examples of general speech and gestures.

It should be noted that because the overall ‘pain sensation’ could be made up of different elements (e.g. throbbing, tingling, pushing, stabbing), the analysis of specificity was based only on those elements that were explicitly depicted in the particular gesture or speech unit being scored. Thus, the above example of specific information in speech (“it’s like when you trap your finger in the door”) was scored with reference to the specificity with which the ‘trapping’ element of the sensation was depicted. However, it is entirely feasible that there could be other elements of the overall sensation (such as a throbbing that accompanies the

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<sup>8</sup> Instances of both types of pressure descriptions occurred within the dataset.

sensation of trapping) that are not indicated in the speech and are therefore not taken into account within the specificity scoring. In other words, the lack of a need for further addition of information refers to the same semantic aspect, rather than to the entire breadth of information about the pain sensation.

Using the same criteria, a second researcher trained in gesture analysis coded the speech and gestures in 6 randomly selected interviews (43 speech units = 19%; 24 gesture units = 21%) for specificity. Cohen's Kappa for speech was  $k = .42$  (74% agreement), indicating 'moderate' agreement [51]. All disagreements were discussed and resolved in line with the criteria and examples within the data (see 4. Discussion for a more detailed consideration of this issue). Applying a correction for unequal base rates this Kappa can be interpreted as reflecting 84% accuracy for speech [see 53, Table 1]). Cohen's Kappa for gesture was  $k = .66$  (83% agreement), representing substantial agreement [51]. Using the adjustment for unequal base rates this can be interpreted as reflecting 91% accuracy between coders.

### **3. Results**

The first stage of the results reports the frequency with which information about pain sensation is represented in speech and gestures. As we were interested in the interplay between speech and gestures in the representation of pain sensation, this stage of the analysis focuses primarily on the gestures occurring with speech units containing information about pain sensation, rather than overall gesture rates. The second stage of the results reports the redundancy analysis, while the third stage provides the results of the specificity analysis and proceeds in two phases: 1) total number of specific and general representations of pain sensation in each modality (speech and gesture), irrespective of the specificity of information in the respective other modality, and 2) the distribution of specificity scores across speech and gesture combinations. The final stage of the results considers the relation between redundancy and specificity scores in the representation of pain sensation. Descriptive

examples are provided where appropriate to further illustrate the findings. All statistical comparisons were made using non-parametric tests in accordance with results yielded by Shapiro-Wilk tests. A criterion alpha level of 0.05 was used throughout.<sup>9</sup>

### 3.1. Representation of pain sensation in gesture and speech

Overall, 51% of speech units contained information about pain sensation (222 out of 439). Of these speech units, 78% were accompanied by gestures (179 out of 222). When considering only those gestures that contained information about pain sensation, 53% of speech units containing information about pain sensation were accompanied by a gesture unit also containing information about pain sensation (117 out of 222). See Table 1 for further descriptive statistics.

Table 1.  
Descriptive statistics (Mean, Standard Deviation, Range) for speech and gesture units containing pain sensation

	Mean	SD	Range
Speech units containing sensation information	7.93	2.55	3 – 13
Sensation speech units accompanied by gestures	6.39	2.88	0 – 12
Sensation speech units accompanied by gestures also containing pain sensation	4.18	2.78	0 – 10

### 3.2. Redundancy of pain sensation

We predicted that even when both speech and gesture contain information about pain sensation, gestures would contribute some unique information that is not contained in speech

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<sup>9</sup> As the interviewer in this study was female and research has indicated differences in pain reported by men and women depending on experimenter gender [54, 55] we subjected our data to a series of independent t-tests to check for differences between male and female participants in terms of pressure applied during pain elicitation, pain intensity rating, word count, and gesture frequency and rate (overall, representational gestures and sensation gestures). The results revealed that there were no significant differences between males and females on any of these variables (all p-values > .05).

We also assessed whether the level of pressure applied by participants was related to their communication about the pain experiences by running a series of correlations between pressure applied during pain elicitation and word count and gesture rates (overall, representational gestures and sensation gestures). The results revealed no significant correlations between pressure level and any of these measures of communication (all p-values > .05).

at all (i.e. gestures will be complementary). The redundancy analysis revealed that while 57% of gesture units represented information about pain sensation that was redundant with that contained in speech, a large proportion (43%) of gesture units represented complementary information about pain sensation that was not contained in the accompanying speech.

A more qualitative consideration of the data revealed that complementary gestures contributed a range of information about the pain sensation, for example by indicating that the pain was throbbing, tingling, pressing or shooting in nature where these aspects of the sensation were not provided within the accompanying speech. For example, one participant verbally described the pain as “sharp” while gesturally depicting a rapid shooting sensation, an aspect of the pain experience that was not alluded to in speech (See Figure 1, Example a). Another participant described the pain in terms of a “heavy pushing down” while producing a gesture which gave the impression of something repeatedly hammering on the finger (see Figure 1, Example b), again something that was not indicated in the accompanying speech. Finally, the gesture in Figure 1 (c) represents the sensation as having a squeezing, clenching element, while the speech simply described the pain as “*quite sharp*”. Taken together this indicates that these gestures serve to provide a fuller representation of the overall pain sensation than speech alone.

(a) “quite like a sharp pain” **[General]**



[fingers of the left hand are rapidly moved outwards and back again]  
**[Specific]**

(b) “like something really, like heavy pushing down” **[Specific]**



[right fist clenched and quickly and repeatedly brought against fingers of left hand]  
**[Specific]**

(c) “quite sharp, it felt quite sharp” **[General]**



[fingers of both hands tensed and squeezed inwards towards the palms in a single slow clenching motion] **[General]**

(d) “If you hit your hand really hard on the door or on a table” **[Specific]**



[Left hand brought across the front of the body and then rapidly swung out to the left hand side in a horizontal motion as if hitting something before being brought back across the body]  
**[General]**

Figure 1. (a), (b) and (c): Examples of gestures containing complementary information. (d): Example of a gesture containing redundant information.

Speech has been transcribed above the images and sensation information is italicised. Images display the features of the gestural movement in a sequential manner and descriptions of the gestural movements are provided in [square brackets] below the images.

The specificity of the information in each modality is shown in **[bold font in square brackets]** alongside the speech and gesture transcription for each example.

### 3.3. Specificity of information in gestures and speech

#### 3.3.1. Specificity of pain sensation across all speech and gestures

Given the difficulties of expressing pain in a verbal manner, and the disambiguating qualities that have been demonstrated for gestures in past research, we predicted that speech would more often contain general information about pain sensation, while gestures would more often contain specific information about this same aspect. As shown in Table 2, when separately considering the specificity of information about pain sensation in speech and gestures overall, it was found that, in speech, sensation was indeed represented in a general manner significantly more often than in a specific manner ( $z = 3.33$ ,  $N\text{-ties} = 2$ ,  $p < .001$ ). For gestures, the same comparison just failed to reach significance ( $z = 1.93$ ,  $N\text{-ties} = 6$ ,  $p = .054$ ). That is, gestures represent information about pain sensation in a specific manner statistically as often as in a general manner. Therefore, while this hints at a slight difference between speech and gesture, contrary to our predictions, we did not find any evidence that gestures tend to provide more specific information while speech provides more general information. Rather, the pattern for both modalities seems to be similar in that, for both, the representation of general information is most prevalent (at least numerically).

Table 2.  
Descriptive statistics (Frequency, Median, Range) for general and specific information about pain sensation when considering all instances of speech and gesture

		General	Specific
Speech	Frequency	146	76
	Median	5.50	3.00
	Range	9.00	8.00
Gesture	Frequency	75	42
	Median	2.00	1.00
	Range	9.00	6.00

### 3.3.2. Distribution of general and specific information across individual gesture-speech compounds

Because we are interested in the interplay between speech and gesture in the representation of pain sensation, for this stage of the analysis we excluded all speech units that were not accompanied by gestures containing information about pain sensation. Moreover, for those speech units accompanied by gesture, the analysis looked at how general and specific information is distributed across the two modalities, taking into account the pattern of interaction for each individual gesture-speech compound (see Figure 1 for examples of the distributions of specificity information across speech and gesture).

Based on the descriptive statistics displayed in Table 3, it appears that information about pain sensation was most often represented in a general manner in both modalities together (i.e., when speech was general, gesture was also general). In other cases, both modalities provided specific representations, but only half as often as both being general. In addition to this, there were cases in which gestures represented sensation in a more specific manner than speech (i.e. speech is general, while the accompanying gesture is specific), while in others the opposite pattern was apparent (i.e. gesture is general manner, while the accompanying speech is specific). Crucially, the former case was the least frequent of all four different types of interaction patterns. Therefore, although gestures do serve to specify the information in speech in some cases, this pattern is not the most prevalent one, which contrasts with our prediction.

Further, the finding that there are many instances in which both modalities represent information at the same level of detail (i.e. speech and gesture both contain general information or both contain specific information) warrants further investigation to establish whether, in these instances, gestures represent the same or different information with respect to speech. That is, the last step in the analysis draws together the redundancy and specificity

analyses for those cases in which the specificity analysis indicates similarity at a more global level, without taking the kind of sensation information that is represented into account. This last comparison is important because, if we find that gestures contain different information to that contained in speech in these instances, then they may still complement speech even without providing a more specific representation.

Table 3.

Descriptive statistics (Frequency, Median, Range) when considering the specificity of information across individual gesture-speech combinations

Speech		Gesture	
		General	Specific
General	Frequency	50	17
	Median	1.0	0.0
	Range	7.0	5.0
Specific	Frequency	26	24
	Median	1.0	0.0
	Range	3.0	5.0

#### 3.4. Complementarity and redundancy between gesture and speech in the representation of general and specific pain sensation information

Given the findings in the previous stage, we were interested in finding out whether gestures still add unique information (i.e. are complementary) when both modalities represent information at the same level of detail (i.e. when both represent general information or both represent specific information). Therefore, for example, describing the sensation of pain as “like something really, like heavy pushing down” in speech, while simultaneously depicting a repetitive pounding sensation in gesture, is providing specific information in both modalities. However, because the information in gesture refers to a different element of the sensation, here the gesture contributes different information to speech and thus is still complementary with respect to speech (Fig. 1, Example (b)). Looking at the data in Table 4, it is apparent that this was the case in almost half of the instances when both modalities were general, and when both modalities were specific, indicating that even when gestures do not serve to



provide a more specific representation than speech, they nonetheless contribute unique information that is not represented in the accompanying speech. This therefore supports the notion that gesture do contribute to a fuller representation of pain sensation, rather than simply replicating the spoken information.

Table 4.  
Frequency [%] of complementary and redundant gestures across specificity pairings in gesture-speech combinations

Speech		Gesture					
		General		Specific		Overall	
General	Complementary gestures	20	[40%]	13	[76%]	33	[49%]
	Redundant gestures	30	[60%]	4	[24%]	34	[51%]
Specific	Complementary gestures	5	[19%]	12	[50%]	17	[34%]
	Redundant gestures	12	[81%]	12	[50%]	24	[66%]

#### 4. Discussion

We aimed to examine the semantic interplay between speech and gestures when both modalities convey information about the same feature of the pain experience, that of pain sensation. In particular, we were interested in whether gestures were able to contribute any additional information about pain sensation that was not contained in speech and whether they conveyed information about sensation in a more specific manner than speech. The results indicate that pain sensation constitutes a large part of participants' verbal pain descriptions, and that spoken descriptions of pain sensation are frequently accompanied by gestures also containing information about pain sensation, namely in over half of the cases.

Further, the findings of the redundancy analysis revealed that even when both modalities contained information about pain sensation, gestures contained unique information about this aspect (i.e. that was not contained in the accompanying speech) in nearly half of instances, suggesting that gestures play an important role in the representation of complementary information about pain sensation and do not merely replicate the verbal message.

These results support the notion that gestures can be an integral part of communication and that gesture and speech interact to produce a more complete representation than is provided by speech alone [2, 4, 12]. In particular, this research supports the findings of previous studies into the semantic interplay of gesture and speech for the communication of both concrete concepts (such as the events in a cartoon) and pain experiences, which have revealed that gestures contribute unique information that is not contained within the accompanying speech [9, 10, 17, 45]. However, the present study differs from previous research by looking at the semantic interplay between speech and gestures when both modalities represent information about the same aspect of the message (pain sensation), whereas previous work has tended to focus on how information about different features of the overall message (e.g. when gestures depict pain location while speech describes pain intensity) are distributed across speech and gesture. Thus, the present findings extend our knowledge by showing that even when both modalities contain information about the same aspect of the message (pain sensation) gestures can still contribute unique information. Further, by looking at the semantic interplay between speech and gestures in the representation of pain sensation, this study strengthens our knowledge of the role of gestures in the communication of everyday experiences and highlights the importance of gestures in providing a fuller representation than speech alone within a more subjective, perceptual domain than has previously been considered.

The results of the specificity analysis did not confirm our predictions. The most prevalent pattern was that both modalities represented general rather than specific information. In addition to this, instances in which gestures were specific while speech was general (i.e. the pattern in line with our prediction), were actually the least frequently represented. However, our last analysis which drew together both redundancy and specificity in representations of pain sensation, showed that in those cases where gestures and speech represented information

at the same level of detail (i.e. both modalities contained specific information or both contained general information), gestures contributed unique information in nearly half of instances. This suggests that even when gestures do not specify the spoken message they nevertheless contribute towards a fuller representation of pain sensation.

The absence of support for the prediction that gestures would predominantly contain specific (rather than general) information about pain sensation suggests that there may be interesting differences in the semantic interplay between speech and gestures within different domains of talk. Contrary to Gerwing and Allison's [16] finding that when communicating about the floor plan of an apartment, speech most often contained general information while gestures contained specific information, here we found that when communicating about pain sensation, information was predominantly general in nature in both modalities. One explanation may be that private, perceptual experiences such as pain may be more difficult to represent in a specific manner in gesture (and speech) compared to more concrete referents that have physical and visible features perceptible in the external world (such as shape, size, and location) and can thus be clearly depicted in terms of these features giving rise to more specific representation, with coding decisions also made easier due to the accessibility of the referent. Thus, the present work highlights the need to learn more about the factors that influence the nature of gestural depictions, their ability to encode different types of semantic information, and the importance of studying the semantic interplay of speech and gestures across multiple domains of talk. As such, this research represents an important first step towards investigating the semantic interplay of speech and gestures during communication about more internal, perceptual experiences.

Given the relatively low Kappa value ( $k = .42$ ) for the reliability of the speech specificity coding, a degree of caution is needed in relation to the finding that (in line with our predictions) pain sensation information was most often represented in a general rather than

specific manner in speech. Where there were disagreements, the researcher responsible for coding the entire dataset (SR) more often scored the information in speech as being general, while the second researcher more often scored it as specific (in 9 out of 11 disagreements). Thus, the prevalence of general information in speech may have been overestimated to some degree during the analysis by the first coder. However, given the small number of disagreements of this nature and good percentage agreement overall (74% agreement; with the low Kappa being due the systematic nature of the disagreements) this bias (if present in the entire dataset) is unlikely to have had any real effect on the pattern of results, other than perhaps making the difference between general and specific speech units less pronounced (and considering the highly significant p-value [ $p < .001$ ] for this particular comparison, it is unlikely that any such bias would actually eliminate this effect). Further, the lack of an overestimation of specific information in gesture (i.e. against our predictions), suggests that there is no consistent bias of the researcher towards the hypotheses in general.

These findings build on initial research into the role of gestures in pain communication by taking a quantitative approach to studying the interplay between speech and gestures in the representation of pain. Thus, while initial studies [43, 44] highlighted the need to consider the role of gestures in pain communication and made some important observations about the functions of individual gestures referring to pain, only by applying the quantitative methods used here can we gain a better understanding of the ways in which gestures and speech typically interact in the representation of pain experiences. That is, the combination of both types of approaches - detailed qualitative analyses of individual gestural phenomena and quantitative analyses establishing systematic patterns for the combined use of the speech and gesture modalities - seems like a promising avenue for research aiming to provide us with a thorough understanding of the functions of gestures in the context of pain communication.

The present findings have important implications for pain communication within medical and other health-related settings as pain sensation is one of the key features of the pain experience that doctors, nurses and other health professionals must attempt to understand in order to provide adequate treatment and support [47, 48]. However, despite the problems of adequately verbalising pain sensation, to date the primary means of communicating about this aspect has been verbal, with attempts to consider ‘nonverbal’ means of communication tending to focus on more generic indicators of pain presence such as facial expression [56-59]. Thus, these findings highlight the need to encourage addressees (such as doctors, nurses and family members) to attend to the information in gestures in order to obtain as full and precise understanding of the pain experience as possible. This is particularly important in light of the finding that doctors frequently orient their gaze away from patients and look at patient records while listening to patients’ descriptions [60-64].

Naturally, the present study has some limitations. Firstly, it could be argued that as the present study only considered the information contained in gestures in relation to the speech in the corresponding ideation unit [50], this does not take into account whether information is conveyed elsewhere in the spoken description. However, it should be noted that the ‘ideation unit’ approach employed here goes beyond previous studies of the semantic interplay of speech and gesture, which have typically only considered the information in speech at the level of the individual clause [e.g. 17, 64]. Thus, contrary to the ‘ideation unit’ approach, previous work has run the risk of ignoring substantial amounts of semantically relevant information [see 9 for a discussion of this point]. Further, given that an ideation unit provides a semantically complete idea [50], it is unlikely that the information in gestures would correspond to spoken ideations units occurring before or after that with which the gesture occurs. Thus, the present approach can be argued to represent a valid way to assess the semantic interplay between speech and gestures in the representation of information about

pain sensation. Nevertheless, it would be interesting to consider the relationship between the information contained in gestures and the spoken description as a whole to assess whether gesture is able to contribute information that is not contained anywhere in speech.

A second possible limitation is that, because the experimental pain apparatus elicited a transient pain experience over which the participants had control, this might have affected the communication of the experience. In particular, participants may have been less motivated to communicate this sensation because they did not require the researcher to help in easing the pain or to provide any real emotional support. Thus, when communicating about a more ‘natural’ pain sensation (such as toothache or back pain) to doctors and other professionals who are able to provide help and support the patterns identified in the present findings may be even more pronounced in terms of the complementarity and specificity of the information in gestures. Thus, future work should aim to extend the present coding system to examine the interplay between speech and gestures in the representation of pain sensation when communicating about more natural pain experiences in medical settings.

## **5. Conclusions**

In summary, the present findings highlight the importance of gestures in providing a fuller representation of pain sensation than would be provided by speech alone, both by representing additional information that is not contained in speech at all and by providing (in some instances) more specific information than that contained within speech, which may help to prevent misunderstanding of the experience. In the context of gesture research, this represents an important step towards examining the semantic interplay of speech and gestures in a more applied and perceptual domain than has previously been studied, and highlights the impact of the communicational context on the nature of the relationship between the two modalities. Further, this research has important implications for pain communication in medical and everyday settings, as it suggests that not only should we “listen to the patient’s

words about the sensation of the pain” [32] but we should also attend to their gestures if we are to obtain a better understanding of the pain experience.

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