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Exploring the Emotional Functions of Co-Speech Hand Gesture in Language and Communication

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Abstract

Research over the past four decades has built a convincing case that co-speech hand gestures play a powerful role in human cognition . However, this recent focus on the cognitive function of gesture has, to a large extent, overlooked its emotional role—a role that was once central to research on bodily expression. In the present review, we first give a brief summary of the wealth of research demonstrating the cognitive function of co-speech gestures in language acquisition, learning, and thinking. Building on this foundation, we revisit the emotional function of gesture across a wide range of communicative contexts, from clinical to artistic to educational, and spanning diverse fields, from cognitive neuroscience to linguistics to affective science. Bridging the cognitive and emotional functions of gesture highlights promising avenues of research that have varied practical and theoretical implications for human–machine interactions, therapeutic interventions, language evolution, embodied cognition, and more.

Keywords: Language; Hand gesture; Emotion; Cognition; Multimodal; Embodied; Communication

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Fig. 1. Images from Darwin's (1872), The Expression of Emotion of Man and Animals. From the Wellcome Trust.

Over the past four decades, the field of cognitive science has gradually moved away from narrowly viewing the human mind as a disembodied and abstract processing device, much like a computer, toward seeing it as a thoroughly embodied one brought to life through physical interactions with the world, more like a living organism (Barsalou, 1999; Clark, 1998; Damasio, 1996; Glenberg & Kaschak, 2002; Johnson, 2007; O'Regan & Noë, 2001; Wilson, 2002). At the front edge of this trend has been research on a ubiquitous bodily action once seen as outside of cognition: co-speech hand gesture. With the pioneering work of Susan Goldin-Meadow, David McNeill, and Adam Kendon (Church & Goldin-Meadow, 1986; Kendon, 1986; McNeill, 1985), we now appreciate that the hands do more than just reflect cognitive aspects of the mind, they actually constitute it. Although this groundbreaking research has led to a much better understanding of the cognitive function of gesture, many have lost sight of another function—its *emotional* purpose—that originally dominated the study of bodily expression, but has been largely ignored in recent research on co-speech gesture. In the present review, we revisit this function to widen the lens and bring emotion back into the picture, with the goal of better understanding why we gesture when we speak, cognitively *and* emotionally.

1. Historical roots

The study of gesture as a form of rhetoric goes back to antiquity (Kendon, 1983), but only relatively recently has it been a subject of scientific investigation. The most prominent scientific work first associated with the study of bodily expressions was Charles Darwin's 1872 book, *The Expression of Emotion of Man and Animals*. In its nearly 400 pages, filled with some wonderfully expressive images (see Fig. 1), Darwin outlined the many ways in which the human body—face, voice, body, and hands—expressed a dynamic range of emotional information. Darwin argued that just as with our nonhuman relatives, these emotional expressions are key to our survival: "The movements of expression in the face and body, whatever

their origin may have been, are in themselves of much importance for our welfare" (p. 365). And he noted their particular importance when combined with speech: "The movements of expression give vividness and energy to our spoken words. They reveal the thoughts and intentions of others more truly than do words, which may be falsified" (p. 366). Although much of his focus was on the emotional expression of the face, he did touch on the *linguistic* function of the body too: "The force of language is much aided by the expressive movements of the face and body" (p. 355).

Although Darwin's book was widely read at the time, it languished and landed in relative obscurity for decades (Ekman, 2006). This changed in the mid-20th century when audio and video recording technology became widely available as a research tool to study language and communication. Cutting-edge work by Ray Birdwhistle, Michael Argyle, and Adam Kendon (among others) used audio-video recordings to bring Darwin's observations to life in the fields of linguistics, anthropology, psychology, and psychiatry. This work gained prominence with the publication of a pair of widely cited studies by Albert Mehrabian in 1967 (Mehrabian & Ferris, 1967; Mehrabian & Wiener, 1967) showing that nonverbal channels (facial expression and tone of voice) communicate much more affective information than the verbal channel in ambiguous messages. Riding this wave of popularity was Paul Ekman's highly influential research on universal facial expressions (Ekman & Friesen, 1969). Over the next two decades, Ekman's work became the face of research on nonverbal behavior (Ekman, 1999), and by the 1980s, the term "nonverbal" had a clear and well-established connotation: It was an extra-linguistic channel that expressed a range of emotional, attitudinal, and cultural information. This led most linguists and cognitive psychologists to view bodily communication as outside the proper and central study of language and cognition (McNeill, 1985).

It was in this context that David McNeill (1985) published his provocatively titled *Psychological Review* paper, "So you think gestures are nonverbal?" In it, McNeill focused on the pervasive bodily action of co-speech hand gestures and theorized that far from being mere affective "add-ons" to language, these hand movements were tightly integrated with speech and together mutually constituted the cognitive machinery of the mind. Acknowledging that some psychologists and psychiatrists (but not linguists) had already viewed speech and gesture as part of a single psychological structure, McNeill went a step further and completely dissolved the distinction between gesture, language, and thought: For McNeill, gesturing with the hands *was* thinking with language in visuospatial form (McNeill, 1992).

McNeill's work on adult gestures dovetailed with developmental research by Susan Goldin-Meadow who had already done groundbreaking work on the spontaneous "home-sign" gesture systems created by deaf children of hearing parents (Goldin-Meadow & Feldman, 1977). This work showed that the hands could carry the full burden of language, even in the absence of conventional input. Together with research on adult sign language (Stokoe, 1960), this work clearly established the hands as powerful cognitive tools for expressing the intricacies of language and thought. Nearly a decade later, Goldin-Meadow and her student, Breckie Church, discovered a powerful new function of gesture in a context not when the hands replace speech, but when they *accompany* it (Church & Goldin-Meadow, 1986). This was

the first study to demonstrate that: (1) co-speech gestures could reveal children's conceptual knowledge that was not present in the semantic content of their speech, and (2) these gestures actually reflected children's transitional understanding of new concepts. This work introduced a new cognitive twist on the phenomenon of "nonverbal leakage," in which the body expresses different emotional content as speech (Ekman & Friesen, 1969).

Together, these early studies by McNeill, Goldin-Meadow, and others took "nonverbal communication" out of the domain of emotional and extra-linguistic expression and brought it squarely into the realm of cognitive science. This move gave rise to the field of Gesture Studies, which over the next several decades, has shown that bodily gestures are a key part of the linguistic and cognitive workings of the mind.

2. The cognitive function of gesture

The field of Gesture Studies has grown too large to review it all here, so we just sample some highlights with the goal of showing just how far gesture has moved from the emotional realm into the cognitive one. Specifically, we focus on the cognitive domains of language acquisition, learning, and thinking.

2.1. Language acquisition

One of the strongest claims about gesture as a foundation for language and cognition comes from Michael Tomasello's work (Tomasello, 2010). Tomasello argues that the most unique feature of human cognition is shared intentionality, which "refers to collaborative interactions in which participants have a shared goal (shared commitment) and coordinated action roles for pursuing that shared goal" (Tomasello, Carpenter, Call, Behne, & Moll, 2005, p. 680). Tomasello argues that the phylogenetic and ontogenetic roots of this innate cognitive skill are inextricably tied to human gestures. Evolutionarily, the unique way that humans use deictic gestures to cooperate and establish common ground—pointing to show interest or to offer help—and use iconic gestures to represent thoughts—pantomiming object attributes, actions, and spatial relations—served as the cognitive foundation on which conventionalized language evolved (Tomasello, 2010). Developmentally, these gestures precede various stages of language acquisition (Bates, 1976) and provide a cognitive and social scaffold in which children acquire language (Goldin-Meadow, 2003).

Some of the clearest work showing a link between early gesture use and language acquisition was done by Goldin-Meadow and her students (Goldin-Meadow, 2003). Children's deictic gestures (pointing to a ball to request it) predict one-word speech (Butcher & Goldin-Meadow, 2000). Then, at the one-word stage, the number of iconic gestures (making a gesture to represent a ball) outpaces the number of words learned (Iverson et al., 1994). After spoken vocabularies catch up to gestures, the two modalities are frequently used in supplementary ways (making a ball gesture and saying "Gimme") (Morford & Goldin-Meadow, 1992), and these combinations predict the onset of two-word speech (Butcher & Goldin-Meadow, 2000;

Iverson & Goldin-Meadow, 2005). In terms of language comprehension, there is evidence that parents gesturing to their children at 18 months of age is positively correlated with language abilities 2 years later (Rowe & Goldin-Meadow, 2009).

2.2. Learning

The cognitive benefits of gesturing continue well after childhood and outside the realm of language development. For example, building on the preliminary work of Church and Goldin-Meadow (1986), we now know that producing certain gestures with speech not only reveals transitional knowledge in 7-year-olds, but actually propels learning itself (Goldin-Meadow, 2003). Gesturing about things not contained in speech materializes ideas and concepts that can be readily integrated into more sophisticated thinking about a task. This extends to older children and adults and spans many different conceptual domains: learning about mathematical concepts (Goldin-Meadow, Cook, & Mitchell, 2009; Perry, Church, & Goldin-Meadow, 1988), analogical reasoning (Jee & Anggoro, 2019), spatial processing (Chu & Kita, 2011), and creative problem-solving (Goldin-Meadow & Beilock, 2010; Kirk & Lewis, 2017; Thomas & Lleras, 2009). The benefits of gestures go beyond learners producing them—the gestures produced by teachers also powerfully shape the learning process. For example, Alibali and Nathan (2012) show that students' and teachers' gestures capture embodied knowledge of mathematical concepts in the classroom, suggesting that the hands not only reflect conceptual knowledge, they powerfully communicate it as well.

This cognitive benefit of producing and seeing gestures has also been well established in the context of second language (L2) learning (Gullberg, 2008). For example, many grammatical, lexical, and pragmatic differences seen between languages are also reflected in gesture differences (Kita & Özyürek, 2003), and these are very much part of the L2 learning process. Gestures also play a social role in communicating L2 content between learners and teachers. L2 learners benefit from seeing gestures, and attention to this information affects the brain's imagistic and motor processing of new words (Kelly, McDevitt, & Esch, 2009; Macedonia, Müller, & Friederici, 2011).

2.3. Thinking

Over the decades, there have been many cognitive explanations for why people gesture when they speak. In the 1990s, there was a spirited debate between David McNeill and Robert Krauss about the cognitive relationship between speech and gesture. Whereas Krauss claimed that people produced gestures primarily to help access words while speaking (Morrel-Samuels & Krauss, 1992; Rauscher, Krauss, & Chen, 1996), McNeill argued that gestures and speech were more on equal footing, with the two modalities manifesting thought in two representationally different, but mutually influential, ways (McNeill, 1992). With the rise of embodied cognition (Barsalou, 1999; Glenberg & Kaschak, 2002; Wilson, 2002), McNeill's view won out, and the field has come to accept that gesture is a fundamental aspect of thought, not simply a standby for speech (Church, Alibali, & Kelly, 2017; McNeill, 2008).

More recently, these ideas have been fleshed out into even more explicitly "embodied" frameworks. For example, Goldin-Meadow and colleagues see the production of gestures as a way to externalize spatial thinking and to free up cognitive resources during speech production (Goldin-Meadow, Nusbaum, Kelly, & Wagner, 2001). More broadly, Hostetter and Alibali (2008, 2019) proposed the "Gesture as Simulated Action" framework arguing that gestures are a form of embodied imagery and action that is triggered during speech production when mental simulations cross over and physically activate the motor system. In a similar vein, Kita and colleagues propose the "Gesture-for-Conceptualization Hypothesis," which claims that gestures are a sort of "schematized" representation that can uniquely capture relevant aspects of particular cognitive activities (Kita, Alibali, & Chu, 2017). This situates the hands somewhere between doing and thinking, between actual actions on the environment and abstract thoughts about the environment, giving gestures the benefits of both worlds (Streeck, 2021).

In all models of gesture production (see also de Ruiter, 2000), there is a heavy focus on the cognitive role of these hand movements, with almost no attention paid to emotional components. To appreciate the scope of this imbalance, consider the edited volume, "*Why Gesture*," exploring various functions of co-speech gesture (Church et al., 2017). In 18 chapters with 25 authors and over 400 pages, the words "cognitive," "concept," and "think" appear on 146, 143, and 130 pages, respectively. In contrast, the words "emotional," "affective," and "feel" appear on only 11, 8, and 8 pages, respectively—and many of those appearances urge the field of Gesture Studies to give more attention to the emotional role of the hands.

We have come a long way from Darwin's original claims about how the body expresses emotion. On one hand, that progress has been a boon, because now we have expanded our understanding of the roles of gesture to include not just feeling, but thinking too. But on the other hand, this recent and lavish attention on cognition has come at the expense of considering how the two functions of gesture may work in tandem. In the next two sections, we review the literature on the affective role of co-speech gestures. Then, we present theoretical and practical reasons for uniting the two functions.

3. Emotional functions of co-speech gesture

In a 2021 op-ed in *Scientific American*, Susan Goldin-Meadow (2021) wrote, "Every once in a long while, we see gesture raised to a high art." Goldin-Meadow was referring to the richly expressive gestures of National Youth Poet Laureate, Amanda Gorman. In her poem, *The Hill We Climb*, recited at the 2021 U.S. Presidential inauguration, Gorman's gestures were as much part of her poem as her words were, deepening its meaning in powerful ways (see Fig. 2). Her hands not only helped people visualize what she was saying, but they also allowed the audience to really *feel it* too. Together with her dynamic facial expressions and creative vocal prosody, her gestures and words invited the audience to emotionally connect to her message. For example, in Fig. 2, when Gorman said, "We've braved the belly of the beast," she tilted her body and head slightly to the right, made a wary facial expression, and

Fig. 2. Amanda Gorman reciting, "*The Hill We Climb*." "We've **braved the belly** of the beast." (Bold = gesture). Copyright permission from Getty Images. For the full poem: https://www.youtube.com/watch?v=LZ055ilIiN4

used her two hands to metaphorically push away from that danger. As a viewer, you could almost feel yourself recoiling too.

So, what is the empirical evidence for the emotional role of co-speech gestures?[1] We start with the expressive function of gestures for speakers and then discuss how grasping those expressions affects comprehension in viewers.

3.1. Expressing emotion

Although the focus of this review is on co-speech gestures, the prominent role of emotion in conventionalized sign languages must first be acknowledged. Sign languages all around the world express emotion not only through the hands, but also the torso, head, and face (Baker & Cokely, 1980; Brentari & Crossley 2002; Dachkovsky & Sandler, 2009; Elliott & Jacobs, 2013; Reilly, McIntire, & Seago, 1992). Much of this multimodal expression is obligatory and codified—it is very much *part of* the sign—but some of it is spontaneous and idiosyncratic. For example, Reilly and colleagues showed that native signers adjust the speed and size of their manual signs when communicating identical semantic content with different emotional valences (specifically, sad and angry), and interlocutors use this information to gauge the emotional meaning of the utterances. Although the hands alone can communicate emotional messages, the combination of the hands and nonlinguistic facial expressions further

[1] Although there are individual differences (Nagels, Kircher, Steines, Grosvald, & Straube, 2015), it is worth noting that many people have generally positive attitudes toward gestures and gesturing (Kelly & Goldsmith, 2004; Nathan, Yeo, Boncoddo, Hostetter, & Alibali, 2019; Salvato, 2020; Sime, 2008; Smotrova, 2017; Sueyoshi & Hardison, 2005; Zheng, Hirata, & Kelly, 2018).

enhances these messages. This indicates that "emotional prosody" is woven through multiple modalities simultaneously, suggesting a pervasive integration of affect into all aspects of a sign's meaning. Given this multimodal expression of emotion in sign, it is interesting to consider the emotional function of *co-speech* gestures, which are much less conventionalized and obligatory than nonmanual aspects of sign.

Much of the early work on emotional expression in co-speech gestures focused on two types: "emblems" and "adaptors" (Efron, 1941; Ekman & Friesen, 1969; Kendon, 1983). Emblems are culturally specific gestures adhering to particular standards of form that have acquired a conventionalized meaning within that culture (and sometimes across it). Some of these are rather neutral, like the "come here" or "can't hear you" gestures, but many are more emotionally charged. For example, the "thumbs up" gesture is a signal of approval in some countries, like the United States and the UK, but it is a grave insult in others, like Greece and Afghanistan. Adaptors are hand movements that involve touching the body—wringing the hands, playing with hair, scratching one's arm—or manipulating objects, such as twirling a pen and playing with a ring. These are traditionally seen as expressions of negative emotions, like boredom, anxiety, and stress (Ekman & Friesen, 1969), or certain undesirable personality traits, such as "neuroticism." Indeed, people scoring high on neuroticism are more likely to engage in self-touch (Waxer, 1977) and less likely to gesture toward others in conversation (Argyle, 1988).[2]

More recent work has moved beyond emblems and adaptors, which can occur independently of speech, to consider the emotional function of gestures that *require* speech. Hedda Lausberg has been an early leader on this front through her creation of NEUROGES® (the Neuropsychological Gesture System), a computer-assisted system for analyzing co-speech hand gestures in naturalistic contexts (Lausberg & Sloetjes, 2009). The system has been particularly useful as a diagnostic tool in neuropsychology, psychodiagnostics, and therapist–patient interaction. There has been growing interest in how a wide range of co-speech gestures reflects the emotional states of individuals diagnosed with psychological disorders. For example, lower co-speech gesture production is associated with "negative symptoms," such as monotone speech and blunted facial expressions, in patients diagnosed with schizophrenia (Marder & Galderisi, 2017). This relationship between gesture and affect is so strong that "deep learning" neural networks have even been trained to use the size and speed of gestures to differentiate positive and negative mood states in patients with bipolar disorder (Yang et al., 2018).

Co-speech gestures serve an emotional function in neurotypical populations too. For example, the growing field of "sensory linguistics" considers co-speech gestures to be a powerful (but underexplored) tool in the everyday expressions of sensory experiences, which are often rich with affective and emotional content (Winter, 2019). One particularly charged sense that has received recent attention is pain (for a review, see Rowbotham, Lloyd, Holler, & Wearden, 2015). In one study, Rowbotham and colleagues found that 53%

[2] But see Hostetter and Potthoff (2012) for evidence that in a laboratory setting, people scoring high on neuroticism produce fewer adaptors than co-speech representational gestures.

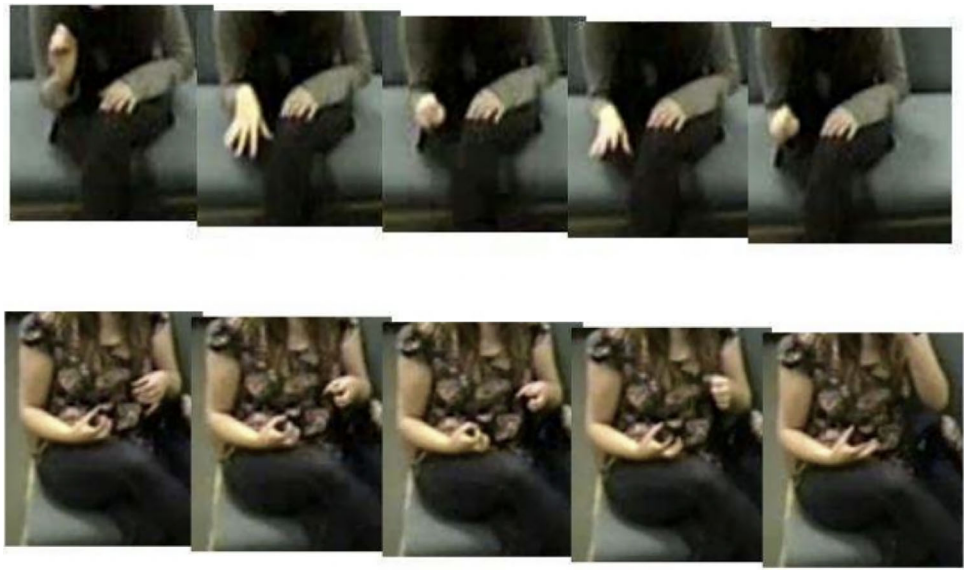

Fig. 3. Still frames from Rowbotham et al. (2014a).

of the gestures that accompany "pain speech" conveyed information about that pain, with almost half of those gestures (43%) adding complementary information about the pain to the accompanying speech (Rowbotham, Holler, Lloyd, & Wearden, 2014a). For example, gestures disambiguated speech by adding unique and specific information. One participant vaguely described how the feeling was "quite like a sharp pain," while clenching and opening their fist rapidly, throwing it outward and inward repeatedly, indicating the pain's speed, frequency, and directionality (Fig. 3, top). In other instances, gesture and speech mutually disambiguated each other: Another participant verbally described how pain "felt quite sharp," while making a slow clenching gesture. Alone, the speech and gesture are vague, but when combined, they reveal that the sharp pain is a slow squeezing feeling, rather than an abrupt stabbing one (Fig. 3, bottom). Further research has also revealed how gestures, independent of the face, serve as an assessment of pain severity (Rowbotham, Holler, Lloyd, & Wearden, 2012; Rowbotham, Wardy, Lloyd, Wearden, & Holler, 2014b).

Beyond the expression of physical emotions, "metaphoric" gestures can convey more abstract feelings. In McNeill's *Hand and Mind* (1992), he describes a speaker using his right hand to represent "good guys" and his left hand to "bad guys," suggesting a metaphoric mapping of good with right and bad with left (see also, Bressem & Müller, 2017, Casasanto, 2009; Müller, 2013). In the domain of moral reasoning, Church, Schonert-Reichl, Goodman, Kelly, and Ayman-Nolley (1995) showed that gesture captured abstract conceptual information when people talked through emotionally charged Kohlbergian moral dilemmas (e.g., one subject said, "[He should do it] because he loved his father," while moving his left hand to near the heart). Building on this, Beaudoin-Ryan and Goldin-Meadow (2014) found that 12- to 13-year-old children often produced gestures that provided different perspectives than

speech when explaining these dilemmas, and it was these children who were more likely to "advance" in their moral reasoning. Although this gesture research has focused on moral cognition, the role of emotion in moral reasoning is significant (Haidt, 2001; Paxton & Greene, 2010), opening up new lines of research on how gestures may reflect cognitive and socioemotional processing in moral judgment.

Another rich context for emotional gestures is acting. "Surface acting" is a technique for capturing emotions that requires an actor to produce particular facial expressions, body postures, and hand gestures to instigate deeply felt emotions (Hochschild, 1983). Blix (2007) shares this quote from a stage actor: "Sometimes it can be useful to start from the outside… it is possible to release a lot of feelings and desires and the lines can start to flow if you adopt a special body pattern" (p. 167). In this way, there is a self-reinforcing cycle: The emotional expression of the body feeds inward on the emotional state of the actor, and this feeds outward and enhances the emotional expression (Laban & Ullmann, 1971).[3] This embodiment of emotion connects up with an actor's speech content and prosody too. In an analysis of film actors in *Death of a Salesman*, Kipp and Martin (2009) found a correlation between emotional content in spoken utterances and gestural dimensions, such as handedness and motion of gestures (e.g., outward gestures were correlated with verbal aggressiveness) (see also Dael, Goudbeek, & Scherer, 2013; Wallbott, 1998).

On the subject of acting, political rhetoric is another wellspring for emotional gestures. In addition to using emblems to add emotional and cultural meaning to a message (Kendon, 1983), political speeches also use deictic (pointing), beat (emphasizing enumerated talking points), and metaphoric ("rise up" or "settle down") gestures to orchestrate the emotional tone of different parts of a speech (Bull, 1986). These gestures go hand in hand with other emotional elements of the performance, such as vocal prosody, eye gaze, facial expression, and body posture, and all together can transform the message of a speech (for case studies, see Calbris, 2003; Poggi & Vincze, 2008; Streeck, 2008). It is worth pointing out that for some political rhetoric, channeling emotions is *more* important than conveying informational content. This is an intriguing case where the affective function of gesture may supersede the cognitive one. This harnessing of emotions through the body is especially powerful and possibly dangerous in political discourse that targets marginalized and vulnerable groups (see Hart & Winter, 2021, for a contemporary example).

Finally, emotional gestures are increasingly relevant to the context of human–machine interactions (Becker, Kopp, & Wachsmuth, 2004; Cassell & Thorisson, 1999; de Wit, 2022; Kopp, 2017; Wang & Ruiz, 2021). Since the turn of the millennium, there has been growing interest in "affective computing" (Picard, 1997), which deploys automated emotion recognition systems to analyze and respond to users' multimodal signals (Calvo & D'Mello, 2010; Castellano, Kessous, & Caridakis, 2008; Noroozi et al., 2018). For example, Castellano et al. (2008) trained a Bayesian classifier algorithm to analyze facial expressions, hand gestures,

[3] Laban is most known for emotional expression in dance. The emotional connections between gesture and dance—and their link to music in the evolution of language —are fascinating and deserve more empirical attention.

and speech acoustics (e.g., pitch patterns, stress, amplitude) to detect emotions from a multimodal corpus of 10 speakers enacting eight different emotions. The algorithm was able to correctly categorize the emotions best (78.3% of the time) when it used all three multimodal cues, suggesting that emotional expressions are synchronized and fused across multiple modalities (see also Yang & Narayanan, 2014). Importantly, most current algorithms ignore the semantic content of speech, but with recent advances in natural language processing (e.g., Chat-GPT), computer programs that analyze multimodal emotional expression *in actual linguistic contexts* may soon lead to major advances (Barrett, Adolphs, Marsella, Martinez, & Pollak, 2019).

Consistent with Darwin's original claims about bodily expressions, recent research clearly shows that co-speech gestures reveal a window into human emotions. Next, we turn to the other side of this question: How do these hand gestures get emotionally understood by others?

3.2. Grasping emotion

Traditionally, the vast majority of empirical work on "nonverbal" emotional perception has studied the face (Dael, Mortillaro, & Scherer, 2012; de Gelder, 2009). For example, in the field of affective neuroscience, Beatrice de Gelder (2009) estimated that 95% of the published research focused on facial expressions, largely ignoring the hands and body. This is starting to change in the field of affective science (see Keltner, Sauter, Tracy, & Cowen, 2019), and the shift meshes well with recent frameworks in diverse fields—cognitive science (Holler & Levinson, 2019), psycholinguistics (Clark, 2016), social development (Keating, 2016), and neuroscience (Skipper, 2015; Yang, Andric, & Mathew, 2015)—nesting co-speech gestures in a larger bodily context. This makes the question of how we grasp emotion from the hands more relevant than ever.

Because emblems and adaptors clearly communicate about emotional states, it is not surprising that viewers are quite sensitive to them. Certainly, anyone on the receiving end of an offensive gesture knows the power of the hands to quickly elicit strong emotions! But these gestures can be used for good, too: A recent study showed that when learners of Japanese produced culturally familiar emblems (holding the bridge of the nose while saying, "It's spicy"), native Japanese speakers judged those L2 speakers as less nervous and more confident than when they produced no gestures or culturally unfamiliar ones (fanning the mouth, which is more common in China) (Billot-Vasquez, Lian, Hirata, & Kelly, 2020). Adaptors, on the other hand, mostly send negative messages. In one study, participants watched scripted speeches of a "politician" (a female actor) producing different types of gestures, and observers judged her to be less composed when she produced self- and object-adaptors versus representational gestures (Maricchiolo, Gnisci, Bonaiuto, & Ficca, 2009; see also Carli, LaFleur, & Loeber, 1995).

When it comes to comprehending representational gestures, like iconics and metaphorics, most experiments focus on neutral stimuli (Dargue, Sweller, & Jones, 2019; Hostetter, 2011; Kelly, 2017). Even when emotionally charged stimuli are used, as with McNeill's *Canary Row* paradigm, the attention is on the cognitive elements of gesture comprehension (Cassell, McNeill, & McCullough, 1999). Recently, this has started to change, and there are

now a handful of experiments that have explicitly investigated how emotional content modulates gesture-speech processing (Asalıoğlu & Göksun, 2022; Chan & Kelly, 2021; Guilbert, Sweller, & Van Bergen, 2021; Levy & Kelly 2020). For example, Levy and Kelly (2020) showed people video clips of an actor saying affectively valenced sentences (neutral, positive, and negative) with and without co-speech iconic gestures and then gave a surprise memory test for the *spoken content* of the videos. While gestures greatly boosted memory for the speech content across all three conditions, only the neutral and positive valenced stimuli showed evidence of gestures intruding on memory for speech. For example, for the positively valenced sentence, "My parents gave me a graduation gift," participants often included the word "car" in their recollections of the sentence when an iconic gesture of driving a car accompanied the speech. Similar intrusions were absent for negatively valenced sentences, like "The football player took a hard hit" accompanied by a gesture to the head. This suggests that different emotional valences may affect how people tune in and tune out gesture when encoding and remembering speech (but see Guilbert et al., 2021, for evidence that "redundant" gestures may play a different role in emotionally valenced recall).

There has been growing appreciation that spoken and signed languages are not completely arbitrary systems—rather, they possess varying degrees of *iconicity* (Dingemanse, Blasi, Lupyan, Christiansen, & Monaghan, 2015; Imai & Kita, 2014; Perniss, Thompson, & Vigliocco, 2010). Iconicity is the property of language in which the form of a symbol corresponds to sensory, motor, and/or emotional properties of the referent (Perniss & Vigliocco, 2014). For example, in the case of emotional sound symbolism, this can manifest when certain languages, like German and English, associate negative versus positive valences with phonemes spoken quickly versus slowly (Adelman, Estes, & Cossu, 2018). Moving beyond speech, it is well established that hand gestures can also communicate iconicity about all sorts of concrete things, such as actions, object attributes, and spatial relations (Church et al., 2017). The communicative power of iconic gestures works for emotions too (Fay, Lister, Ellison, & Goldin-Meadow, 2014; Kita, 1997). For example, Fay et al. (2014) had people play a communication game, where players generated meaning from scratch without conventionalized language. They found that iconic gestures alone were better than vocalizations alone in successful communication of emotional content. Although the study by Fay and colleagues did not find any benefits of adding vocalizations to the gestures, Perlman and Cain (2014) argue that "multimodal iconicity" is particularly effective at communicating emotional meaning.[4]

Perhaps the most systematic investigation of how people grasp emotion from the body comes from the work of Beatrice de Gelder. Broadening previous research focusing on the face and voice, de Gelder asks how the rest of the body interacts with these channels to create an integrated whole (de Gelder, 2006, 2009). For example, Van den Stock, Righart, and de Gelder (2007) found that when facial expressions and voice matched emotional expression of the body, the perceived emotion was amplified. This wholistic processing can also be seen at a neural level: Fearful body and facial expressions are both processed by the amygdala and the

[4] For a wonderful illustration of this, Perlman and Cain (2014) share this example of a man vividly describing a car accident: https://www.youtube.com/watch?v=uuDvAeZE9ME.

right middle fusiform gyrus (Hadjikhani & de Gelder, 2003), and there is a convergence region in the left lateral temporal cortex that is more active when both face and voice are presented together versus alone (Pourtois, de Gelder, Bol, & Crommelinck, 2005). Moreover, in terms of temporal processing, the brain perceives emotion conveyed through bodies as rapidly as faces (Flaisch, Schupp, Renner, & Junghöfer, 2009; Gliga & Dehaene-Lambertz, 2005; Meeren, van Heijnsbergen, & de Gelder, 2005; Stekelenburg & de Gelder, 2004). However, at times, the face and the body can compete with one another during emotional processing (Aviezer, Trope, & Todorov, 2012; Meeren et al., 2005; Wood, Martin, Alibali, & Niedenthal, 2019). Indeed, Meeren et al. (2005) showed that when emotions in the face and the body conflicted, bodily expressions disrupted the neural processing of facial expressions within 115 ms.

Because much of this work does not specifically target the hands, it is interesting to ask about their particular role in multimodal emotional processing. There is some recent evidence that the hands are quite important, at least for certain emotions: Ross and Flack (2020) had people evaluate pictures of fearful and angry emotional body postures, and when the hands were digitally removed from the pictures, it made the task much harder (interestingly, removing the hands did not affect evaluations of happy and sad postures). In one of the few studies specifically targeting the emotional perception of hands and faces together (see also Redcay & Carlson, 2015; Vicario & Newman, 2013), Wood et al. (2019) showed that people were faster to categorize the valence of dynamic facial expressions and emblem gestures when they were emotionally congruent versus incongruent (e.g., a happy vs. angry face accompanied by a "thumbs up" gesture), even when the other modality was irrelevant to the task. Building on this research, future studies should explore less conventionalized co-speech gestures, which are pervasive in everyday language (McNeill, 1992).

Compared to the boom in cognitively oriented research over the past 30 years (Church et al., 2017), much less work has explored how people grasp emotional meaning from gestures, especially co-speech gestures. In the final section, we finish by discussing theoretical and practical reasons for studying emotion and language *together* and explore the implications of such a multifaceted approach.

4. Bridging language, emotion, and gesture

Starting with the Cognitive Revolution of the mid-20th century, the study of language has become increasingly enmeshed with the study of cognition (Harris, 2006). Although the same historical trend has been slower regarding the relationship between language and emotion (Barrett, 2006), affective science is increasingly connecting language and emotion in fresh and creative ways (Barrett, 2017; Lindquist, 2021; Majid, 2012; Liebenthal, Silbersweig, & Stern, 2016; Vigliocco et al., 2014). This link highlights exciting new avenues for gesture research, and below we explore four ways in which connecting emotion to language may further enrich our understanding of gesture.

The field of affective science is starting to embrace what Lisa Feldman Barrett calls a "constructivist" theory of emotion (Barrett & Satpute, 2019; Lindquist, Satpute, & Gendron, 2015). This approach rejects the traditional view that emotions are stable, discrete, and spe-

cialized entities that can be understood independently from context. For humans, perhaps the most pervasive and unique "context" for emotion is language. According to constructivist theories, language does more than merely convey emotional information—it actually *constitutes* it, both when expressing and perceiving emotions. Indeed, just as having a label for something can help humans perceive and categorize that thing (Lupyan, 2012), having words for emotion can guide and organize perceptions and interpretations of that emotion (Lindquist et al., 2015). Given that gestures are such an integral part of language (Goldin-Meadow, 2003; McNeill, 1992), this means that hands likely shape emotions too. This has many practical implications. For example, in clinical contexts, because putting emotions into words can get clients in touch with their emotions, encouraging hand gestures may help to reveal, or even provoke, feelings that may not otherwise be verbally accessible (for a cognitive analog, see Broaders, Cook, Mitchell, & Goldin-Meadow, 2007). In other cases, gesturing while speaking during therapy may enhance the benefits of affective labeling on reappraising one's emotions, as with cognitive behavioral therapy (Kircanski, Lieberman, & Craske, 2012). Or given the growing recognition of the importance of emotions in educational contexts (Brackett, Bailey, Hoffmann, & Simmons, 2019; Immordino-Yang & Damasio, 2007; Schonert-Reichl, 2019), gestures may help students and teachers to not just better organize and coordinate their thoughts, but manage and align their feelings too (Smotrova, 2017). These are just a few of the exciting practical questions that arise when expanding the function of co-speech gestures to include emotion and cognition.

The study of creativity is a second promising area for uniting language, emotion, and gesture. Cienki and Mittelberg (2013) show that through variations of intensity, repetition, and size, co-speech gestures work together with the face, body, and voice to bring creative thinking and expressions to life. A particularly fertile medium for this gestural creativity is metaphor expression (Lakoff & Johnson, 1980). With specific regard to emotional expression, Kövecses (2003) points out that although superficial details vary across cultures, most metaphors for emotion share the generic feature of "Causes of Force" (e.g., Anger = Pressurized Container). These "force metaphors" lend themselves perfectly to co-speech gestures because the hands are excellent at simulating actions of (and on) things (Hostetter & Alibali, 2008; 2019). Indeed, Cienki and Müller (2008) argue that gestures are an underappreciated vehicle for metaphor that offer depth and nuance of meaning, meanings often missed by focusing on words alone. Specifically with regard to emotions, Kappelhoff and Müller (2011) make the case that multimodal metaphors bring emotions to life by simulating "felt experiences" in the body in a similar way to how film provokes feelings in viewers (see also, Johnson, 2007). Even when the hands are used for very simple metaphors and idioms, such as Up/Right = Good and Down/Left = Bad, they can affect and change how people think and feel (Casasanto & Dijkstra, 2010; Casasanto & Jasmin, 2010). In the future, questions of how gestures facilitate emotional creativity and metaphoric expression deserve the same attention as the more established investigations of gesture's role in cognitive insight and information processing.

Taking a neuroscience view, there is growing evidence that the body is a key part of the neural network connecting emotion, language, and cognition (De Stefani & De Marco, 2019; Keysers & Gazzola, 2009; Liebenthal et al., 2016; Lindquist et al., 2015; Niedenthal, 2007). For example, Liebenthal et al. (2016) present a two-stage model of emotional processing in which primary sensory areas (visual cortex and auditory cortex) process facial expressions

and emotional vocalizations (shrieking or laughing) by sending "fast" signals to limbic areas, such as the amygdala. Subsequently, this fast processing is modulated by a slower process in which nonsensory areas (e.g., middle and superior temporal gyri) analyze the semantic content and prosody of spoken words. It is interesting to consider how beat gestures, which are tightly integrated with spoken prosody (Bosker & Peeters, 2021; Krahmer & Swerts, 2007), fit within this network. In addition to this cortical-limbic pathway, another key part of the emotional language network is the putative mirror neuron system (pMNS) in humans (Rizzolatti & Arbib, 1998). The pMNS traverses sensory-motor areas (i.e., the premotor cortex, inferior parietal lobule, and middle temporal gyrus), and together with mentalizing areas like the ventral-medial prefrontal cortex (vmPFC), this network neurally resonates not only when two people use spoken language, but also when they communicate via hand gestures (Schippers, Roebroeck, Renken, Nanetti, & Keysers, 2010; see also, Jiang et al., 2012). Schippers and colleagues point out that the pMNS and vmPFC are also involved when people process others' emotions, suggesting that hand gestures may play a role not just in "aligning" our brains to different levels of language and meaning (Menenti, Garrod, & Pickering, 2012), but also in different aspects of emotional experience as well (De Stefani & De Marco, 2019; Fronda & Balconi, 2020). With this neural alignment in mind, future research should explore how different bodily channels—face, voice, hands, eyes—work together in particular ways to simulate and communicate different emotions (Gallese, Keysers, & Rizzolatti, 2004).

Finally, from a linguistic perspective, it seems that the structure of emotional expressions and the structure of language (spoken and signed) may share more features than previously believed (Cavicchio, Dachkovsky, Leemor, Shamay-Tsoory, & Sandler, 2018; Dael et al., 2012). For example, Cavicchio et al. (2018) have shown that people perceive emotional displays less in a holistic and gestalt fashion and more in a compositional way. So, rather than different emotions having entirely unique components, these displays combine smaller parts—that are shared across many emotions—in different ways to create specific emotions. This is similar to how "compositionality" in language works: Smaller units, like phonemes and morphemes, are reused and combined in particular ways to create larger structures, like words and phrases. This led Cavicchio and colleagues to speculate that evolutionarily, the compositional properties of emotional expressions may have provided "an ancient scaffolding upon which, millions of years later, the abstract and constrained compositional system of human language could build" (p. 1). Because sign language is also fundamentally compositional, this account fits well with theories about the role of gesture and sign in the evolution of present-day conventionalized languages (Oña, Sandler, & Liebal, 2019; Sandler, 2018). Even beyond the property of compositionality, sign language—with its interconnected signaling across multiple modalities—is a fertile area to explore how emotions become conventionalized (or not) by the body.

5. Conclusion

Led by the pioneering work of Susan Goldin-Meadow, David McNeill, and Adam Kendon, the past four decades have been an exciting time for research on co-speech gestures. Never before have the cognitive functions of the hands been explored in such depth and rigor. We

now know that they are involved in a range of cognitive activities, such as acquiring language, formulating speech, learning concepts, solving problems, understanding meaning, and materializing thought. However, with the excitement over these cognitive discoveries, the field of Gesture Studies has largely overlooked how the hands also express and grasp emotional meaning. In this review, we gathered research from widely disparate areas—linguistics, education, clinical psychology, neuroscience, human–machine interactions, artistic expression, political discourse, affective science—to make the case that the hands serve powerful emotional functions, not just cognitive ones.

Viewing the hands in this more expansive way highlights exciting questions that bridge cognition and emotion. We can ask: If emotion is partly constituted by language, and language is comprised of speech and gesture, how do the hands shape affective reasoning and spark emotional insight? In what emotional ways does gesture work with the rest of the body during creative thought and metaphoric expression? How do gestures work with other emotional signals to help the brain resonate with other brains in order to share emotional understanding? And does the way we capture emotion in our hands, both through spontaneous co-speech gesture and conventionalized sign, provide clues about the evolutionary origins of language? Exploring big questions like these will contribute to the continuing growth of Gesture Studies as a vibrant and interdisciplinary field.

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