

Mathematical Gesture Theory

Summary. What is a *gesture*? This is a concept which everyone knows, but no one is able to define. In that way, it is similar to its counterpart, *time*.

The concept of gesture is very important in art, philosophy, and communication. Formally, a *gesture* is a system of continuous curves connecting points in space and time. A curve that connects a gesture to another one is a hyper-gesture. We explore the creativity of new music which uses the gesture as a starting point for composition.



The most famous gesture, ‘the’ gesture, is probably the one of God’s Creation of Adam, in the Michelangelo’s well-known fresco in Cappella Sistina, shown in Fig. 19.1.



Fig. 19.1: Michelangelo’s representation of the Divine Gesture from God to Adam.

The importance of gestures in music is crucial: performers learn specific gestures to play musical instruments, and variations of these gestures allow

different musical-acoustic results. These are the changes of loudness, tempo, and pitch. The importance of gestures can also be gleaned from their historical background, as we will see in the following section.

Fig. 19.2 shows an example of an inappropriate use of gestures to change a musical performance. We are not referring to such cases.

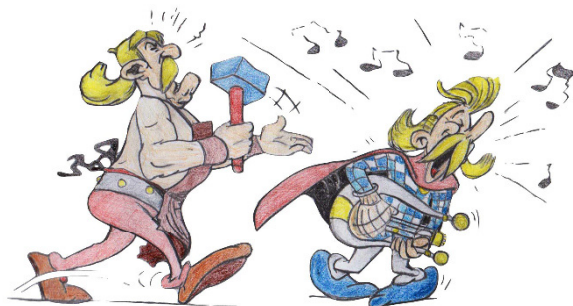


Fig. 19.2: An example of an inappropriate use of gestures to influence and change a musical performance. From the genius of Goscinny and Uderzo.

Western musical notation developed from *neumes*, a system which fixes the shape of the melody and the movements of the choir conductor's hands (chironomic notation) to paper. It is interesting to note that, in a culturally and geographically different environment, musical notation had a similar gestural origin. We have already explored the case of Gregorian music for Western culture. For the Eastern cultures, early Chinese music notation was based on gestures. The notation represented gestural instructions (production) for the player. These were largely created for an instrument called the chin (古琴).

19.1 Historical Roots

Summary. In this section, we will discuss the thoughts of philosophers who emphasized the importance of gestures.



19.1.1 Tommaso Campanella

Tommaso Campanella (1568-1639) was a Dominican friar and theologian who relied heavily on the importance of the senses in his writings. From his text, whose title can be roughly translated to rational philosophy, he discussed five parts: *dialectica*, *grammatica*, *rhetorica*, *poetica*, and *historiographia* [9, 63]. His primary message as it pertains to creative gestures is as follows:

...omnes propositiones per singulares tamquam ad digitum exponuntur.
 ...pointing with your finger is the only certitude.

Campanella simply declares that gestures are the only thing of which we can be completely sure. Gestures do not rely on a byproduct to prove their existence, for a rotation is just a rotation. There may be strokes of paint, but that is only a visible manifestation of the gesture which had to have occurred. Campanella's words speak to the truth that gestures are universal.

19.1.2 Hugues de Saint Victor

Hugues de Saint Victor (c. 1096-1141) was a Saxon theologian. He gives a most adequate definition of a gesture. He describes it as something which is multi-faceted and has factors which must be realized across different realities [62].

*Gestus est motus et figuratio membrorum corporis,
 ad omnem agendi et habendi modum.*

Gesture is the movement and figuration of the body's limbs with an aim,
 but also according to the measure and modality
 proper to the achievement of all action and attitude.

Hugues de Saint Victor declared that gestures have not only motion, but also an attitude. This is essential to the importance of gestures as a concept. Although gestural motion can be reduced to a mathematical formula, the formula will abandon key information which the original gesture held innately. This means that to fully understand artists and their decisions, we must interpret their works at the gestural level.

19.1.3 Paul Valéry

Paul Valéry (1871-1945) was a French poet and philosopher. He was nominated for the Nobel Prize in Literature on 12 separate occasions. In addition to his artistic expertise, he fostered a special interest in optics. His words on art translate well to mathematics and science.

C'est l'exécution du poème qui est le poème.

It's the rendition of a poem which is the poem.
 (The interest of science lies in the art of *doing* science.)

Valéry's philosophy was integral to his pursuits in science. However, he defined a separation between an artistic product (such as poem, painting, or song) and the actual artistic making. To him, the art was not the physical byproduct. The art was in the doing and creating, the gesture. He brought this approach to his scientific studies. He believed that the joy of science was not only in the answers that were found, but even more in the questions that were asked.

19.1.4 Jean Cavallès

Jean Cavallès (1903-1944) was a French philosopher and mathematician who was particularly interested in the philosophy of science. His words surrounding the role of gestures [10] have had an incredible impact in the direction of this book.

Comprendre est attraper le geste et pouvoir continuer.

Understanding is catching the gesture and being capable of continuing.

Cavallès' words are the entire foundation of this topic of gestures; they apply to every aspect of the arts. Imagine that you are an improvising musician in a jazz combo. To play something which involves skill would be to play based upon the context which you receive from your fellow musicians. Of course, there is still room for personal flair. However, it only makes sense that you would generally play in the context which the environment decided.

Imagine that you are a solo painter. To convey a coherent message through your work, your gestures must be linked some how. Even Jackson Pollock's gestures have visible connections between them. Just as an orchestra follows the gestures of their conductor, so does an audience interpret the gestures of a painting.

19.1.5 Maurice Merleau-Ponty

The French philosopher Maurice Merleau-Ponty (1908-1961) beautifully summarized the importance of gesture within communication. He illustrated the symbiotic relationship between the communication of ideas and gestures [50].

La parole est un véritable geste et elle contient son sens comme le geste contient le sien. C'est ce qui rend possible la communication.

Language is a veritable gesture and it contains its sense much as the gesture contains its own. This is what makes communication possible.

Merleau-Ponty combined the ideas of Cavallès and de Saint-Victor. He proposed that a gesture contains information within itself. Connecting these gestures is like stringing together the words of a sentence. Therefore, we are able to create deeper meaning when we link more gestures together. This brings us to the topic of defining gestures and hypergestures.

19.2 Definition of a Gesture

Besides the fact that the use and the concept of gesture is particularly relevant to music, its precise definition is very recent. The mathematical definition of gesture, given by Mazzola [44], is the following. Let's think of a dancer. He or she touches the stage in discrete points, while moving continuously. If we compare

the points to the musical notes, and the continuous curves to the gestures, we can understand their importance for musical performance! And also for composition, because composers also think of final gestures while choosing and writing specific symbols on the musical staff.

Here you are. Let's follow the graphic representation in Fig. 19.3. To the left, we have an abstract structure (music? painting? cooking? nothing yet) of points and connecting arrows, called *skeleton*.¹ To the right, we have a space with the keyboard of the piano indicating the change of position of the hand along this direction to pick a specific pitch, the position above the keyboard (for the 'states' pressed-not pressed key), and the time, the onset. The abstract skeleton is mapped into a system of continuous curves connecting points in space and time, the gesture's *body*. It is clear that we can define gesture for other situations while changing the names of the axis for the space on the right. The number of points and arrows, of course, must be the same. A such mapping is a *gesture*.

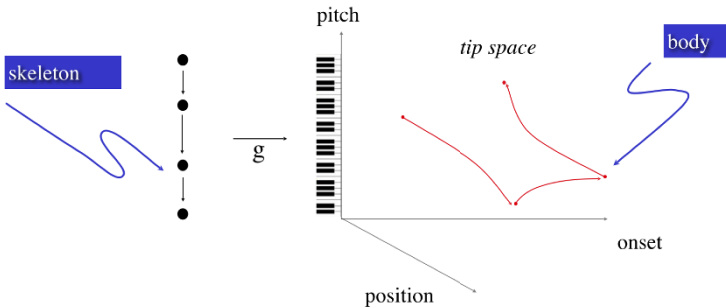


Fig. 19.3: Illustration of the mathematical definition of a gesture, as a mapping from an abstract structure, a skeleton of points and arrows, to a system of continuous curves in space and time, with the same number of points and connecting arrows. The example shown is about the pianistic gesture.

The transformation from notes to sounds is described by the mathematical performance theory of notes [41], from the written information inside the score to the reality of sounds of acoustics. The transformation from gestures 'suggested' by the score into the real movements made by performers, is object of ongoing research, and we already have the first results [36].

How can we get gestures from the score? Let's consider the case of a pianist. If we look literally at the content of a score, we get a series of instructions such as 'play this note at this time with this loudness.' This is more or less what happens for a MIDI instrument! And the change of position should

¹ Points and arrows are the starting spot of the mathematical theory of categories, that has been applied to music by Mazzola [41].

happen *instantaneously*. Not even the world's fastest pianist can play with an infinite speed, because it is not allowed by the laws of physics. Sorry for that.

What happens in reality is that the performers need a *finite* time to make a movement. We call symbolic gestures the curve systems of the first type; physical gestures those of the second one. The surface that transforms a gesture of the first type into one of the second is called a world-sheet, see also the blue-red surface in the middle of Figure 19.5. The name and the way to obtain it (via math-theoretical physical methods) comes from string theory in theoretical physics. Again, another interdisciplinary parallelism: elementary particles in physics are no longer seen as 'points' but as vibrating strings; in a similar way, music can be described not only in term of 'points' but also in terms of gestures. This world-sheet surface is also a hypergesture. We will define it in Section 19.3.

The shape of the surface depends on the choice of the force field that shapes the surface. We will not deal with mathematical details here, but we can say that the force field plays the role of the operators that transform the notes of a score into the sounds [41, 36]. Moreover, the time flowing inside the score and the time of the physical performance are qualitatively different: they represent a simplification of time of mental reality versus physical time, see also Section 16.3 for a mathematical description of this approach.

19.3 Hypergestures

In her book about piano performance, Renate Wieland wrote: "Die Klangberührung ist das Ziel der zusammenfassenden Geste, der Anschlag ist sozusagen die Geste in der Geste." (The sound contact is the target of the embracing gesture, the touch is so to speak the gesture within the gesture). It refers to a more complex concept of gestural utterances. We can make this idea precise in the following sense.

A gesture connects points in space and time. If a gesture is seen as a point itself, the gesture that connects such gesture-points is called *hypergesture*. A hypergesture is a gesture of gestures. Figure 19.4 shows a surface obtained as a loop moving within space along a circle-path.

The concept of hypergesture is very powerful. It helps create incredibly complicated structures of *nested* gestures. An entire symphony, for example, can be studied in terms of hypergestures. With a hierarchical structure, we can describe from top to down the gestures inside an symphonic orchestra. We can think of all the instrumental sections, all the performers of each section, all the micro-movements of the left hand of each violinist This is also a hypergesture. The gestures of each level are composed of smaller gestures of next level.

19.4 A Gesture Suite for Piano

As a *theme* for a musical composition can be built from a melody, a rhythm, a chord, and a timbre. But we can also use a gesture! That's the idea at the base of

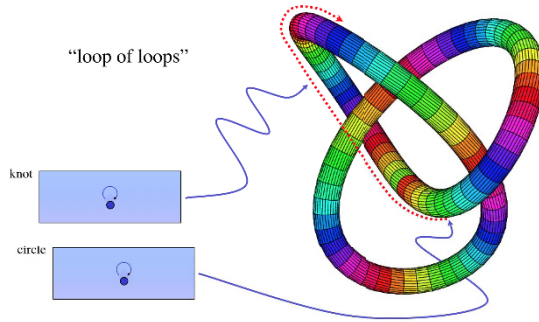


Fig. 19.4: A surface obtained as a loop of loops to represent the concept of hypergesture.

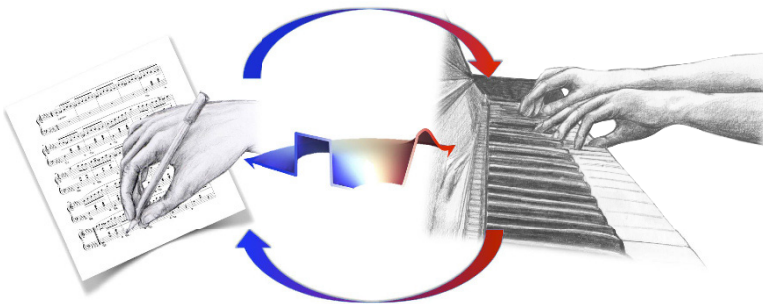


Fig. 19.5: The surface transforming the symbolic gesture into the physical gesture of the musical performance is a hypergesture. From left to right, we have the description of a piano performance; from right to left, the one of the composition from improvisation. Drawings by Maria Mannone.

a recent piano solo suite, *Three Musical Gestures*, composed by Maria Mannone. It is composed of three movements, with variations. The theme is given here by the simple movement up-down in the piano keyboard, the primitive gesture for piano, the one the formalism of world-sheet has been applied to for the first time. The first movement of the suite is *Staccato leggero* (Fig. 19.6), the second *Legato* (Fig. 19.7), and the third *Staccato violento* (Fig. 19.8), with different articulations.²

We can think of isolated gestures—for example a single chord. However, we can also combine such isolated gestures to create a more melodic theme.

² A *movement* inside a musical form always refers to a category of gestures.

We describe such a situation as a collection of circles (isolated gestures) along a hypergestural arrow.³

Three Musical Gestures

Three piano movements in twelve variations

I. *Staccato leggero* Maria Mannone

Largo 1 gesto singolo (cerchio, Asia) in una direzione (freccia, Europa)

(only gestures)

p

11 **Moderato** ♩ = 90

p

19 *mf* *mp* *mf*

p *p*

24

28 **Allegro** ♩ = 120

p *mf* *p*

mf *f*

Fig. 19.6: Beginning of the first movement (*Staccato leggero*) of the piano solo suite *Three Musical Gestures*, where the theme is the simple up-down on a fingertip on the keyboard of the piano.

³ It suggests a synthesis of Asian and Western musical traditions: moving a meditative gesture in a dynamic direction.

II. Legato

92 **Moderato**

(only gestures)

pp *p*

Ped. * Ped. * Ped. *

Fig. 19.7: *Ibidem*, beginning of the second movement, *Legato*.

III. Staccato - violento

150 **Agitato** ♩ = 90

(only gestures)

ff *ff*

Ped. * Ped. *

Fig. 19.8: *Ibidem*, beginning of the third movement, *Staccato violento*.