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*Aspects of touch and timbre
in piano performance. The
effects of key velocity,
articulation and temporal
duration on sound*

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Abstract

The concept of touch in piano pedagogy is generally described by using abstract adjectives often linked to imagination, leading to a blurred and controversial definition of the term touch, often confused with timbre. In the last decades, new data-collection technologies and MIDI-based analysis allowed researchers to measure key-control specific features in timbre nuances modeling [Goebel-Bresin-Galembo 2004; Bernays-Traube 2011, 2013].

Within the field of piano performance, the present study attempts to objectively describe piano touch and the means with which it can be controlled, by: (1) providing elements for an adequate scientific understanding of touch; (2) clarifying the relationship between touch and timbre; (3) defining the extent to which the parameters of key-velocity, tempo and articulation vary as a function of different types of touch.

Aspects of touch and timbre in piano performance

The effects of key velocity, articulation and temporal duration on sound

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Introduction

Within the field of piano performance, the present study attempts to objectively describe piano touch and the means with which it can be controlled, by: (1) providing elements for an adequate scientific understanding of touch; (2) clarifying the relationship between touch and timbre; (3) defining the extent to which the parameters of key-velocity, tempo and articulation vary as a function of different types of touch.

Theoretical background

Piano touch has always been seen as a key element of expression. However, until the first half of the 20th century, the objective lack of adequate methods for measuring musical performance lead researchers and piano pedagogues to approach the physiological mechanisms of piano technique from a primarily anatomical point of view [Breithaupt 1909; Schultz 1936; Kochevitsky 1967; Neuhaus 1973]. In fact, with the exception of very few studies on piano touch specifically undertaken within a scientific framework [Ortmann 1925], the historical piano schools of the 19th century used to express the concept of touch mainly through a large amount of adjectival descriptors, linked to imagination and abstraction. Although fascinating and still very much a part of contemporary teaching methods, this literary approach created a rather blurred definition of touch, sometimes confused with timbre, or even with sound, so that even professional pianists often show some uncertainty in discerning between, defining and describing these concepts.

However, in recent decades, technological developments have provided new directions and theoretical approaches to reflection on music performance. For example, the paradigm of embodied music cognition (EMC) [Leman 2008] has opened up a novel perspective on gestural aspects of expressive performance, in contrast with the classical disembodied view that conceives of physical action and perception as separate entities, focusing instead on the complementarity of action and perception and recognising the human body's central role in influencing processes of musical communication by bringing together matter and mind. Studies have been carried out on expressive gestures in instrumental performance [Camurri *et al.* 2001; Canazza *et al.* 2004; Maes *et al.* 2013], in which touch begins to be objectively investigated as the first step of a more complex analysis of piano skills, involving the entire body's movements. Such an innovative view leads us to reconsider the habitual modalities of music analysis and to consider the point of contact between the performer's body, the instrument and the properties of sound to be a central aspect of any analysis of the processes involved in sound production.

From a highly practical point of view as well, MIDI-based technologies have recently allowed the control of touch on the keyboard to be measured and analysed more objectively and in greater detail [Lee 1989, 1990; Salmon-Newmark 1989; Dalla Bella-Palmer 2004], by detecting subtle features of movement (total kinetic energy, position, velocity, acceleration, finger height, dynamic control, finger-joint force). Other studies have provided insight on timbre and touch, shedding light on the role of hammer velocity and intensity in sound production, and on factors involving gesture and key-control used by pianists to produce different nuances in timbre [Goebel *et al.* 2004; Bernays-Traube 2013], identifying specific patterns in terms of dynamics, attack, key-depression depth, pedalling and articulation.

Nevertheless, despite the progress made in measuring elements of musical performance, an unequivocal definition of touch specifically focusing on the relationship between touch and timbre still needs to be put forward. With this purpose, the present study intends to provide further elements for a scientific approach to the topic. By taking a distance from subjective, metaphorical and literary descriptions of touch, as passed on through historical piano schools, one particular aim is

here to find out to what extent key-control parameters (*key-velocity*, *articulation* and *tempo*) can be influenced by the pianist's ability to specifically focus on different qualities of touch.

So, *in what exactly does piano touch consist, and which features determine its difference from timbre?* Moreover, *how can we recognize pianists' touch only according to the aural features of their sound?*

Method

The research consisted in five steps: (1) acquisition of information on concert pianists' conception of touch and timbre, through a questionnaire; (2) analysis of questionnaires and selection of touch/timbre descriptors; (3) selection of piano pieces to be recorded; (4) recording of expressive performances by five pianists; (5) extraction and analysis of the audio data. A quantitative approach was used for classifying touch descriptors and for MIDI-data analysis, and a qualitative method for interpreting questionnaires.

Participants

Nineteen professional pianists (four women and fifteen men, aged between 28-62), pedagogically active in various Italian cities and internationally experienced performers, were asked to complete a questionnaire. Five of them also played in the recording session.

Questionnaire

The questionnaire aimed at gathering the participants' professional information (education, concerts experience, recordings, teaching activity), a number of definitions of piano touch and timbre, and a list of adjectival descriptors. Questions were presented as openly as possible, in order to leave the participants free to express their ideas.

Piano touch/timbre descriptors

The questionnaires supplied a list of 209 adjectival touch/timbre descriptors, later divided into five semantic categories (physical-motor,

articulatory, sensory, emotional, aesthetic-stylistic). The most recurring adjectives identified for defining touch were *legato*, *staccato*, *light*, *heavy* and *soft* which, as can be easily noted, mainly belong to the articulatory (*legato*, *staccato*) and sensory categories (*light*, *soft*, *heavy*).

Musical fragments

Four fragments were selected from various romantic and modern piano works: Grieg's *Wächterlied* from *Lyric pieces* op. 12, Mendelssohn's *Volkslied* from *Lieder ohne Worte* op. 53 and Takemitsu's *Clouds*. Tempo indications were conserved on the scores, while all agogic and dynamics signs were removed.

Equipment

A Yamaha Disklavier C3 grand piano was used for the recording session, equipped with optical sensors that enabled subtle keys movements to be measured (onset/offset time of keys, and the key-velocity of each note). The performances were recorded both as audio signals (microphone AKG C 414) and MIDI-data (Disklavier's optical sensors and control unit), and also video-recorded with a video camera (Canon MVX330i), capturing a lateral view of the performer's torso, arms and fingers.

Procedure

The nineteen piano performers were requested to give a general definition of keyboard touch and timbre, and to provide a list of their respective qualitative adjectival descriptors, by answering a questionnaire. The five most often recurring touch adjectives were then selected (*legato*, *staccato*, *light*, *heavy*, *soft*), and four musical excerpts were chosen and prepared for the piano recording session, which involved only five performers. The five adjectives were proposed to pianists, to be performed as different examples of touch qualities: the recording procedure consisted in six total executions of each musical fragment, initially in a personal version (*ad libitum*), and afterwards repeated five more times, each time taking one of the five descriptors into account.

It was strictly prohibited to use the pedals, so as to let performers concentrate on their fingers' activity.

Results & Discussion

Questionnaires

Globally speaking, although a number of pianists participating in this study provided very articulated, detailed and interesting reflections on the topic, most of them on the contrary gave brief and simple answers, expressing a rather generic knowledge about mechanisms of touch control. These contributions were nevertheless illuminating, by allowing a realistic understanding of the conception of touch and timbre generally found among professional piano performers. However, a recurring definition of piano touch emerged from these contributions, conceived as the result of the relationship between three elements: (1) the expression of the performer's musical thinking, imagination and ability to communicate feelings and ideas; (2) his/her bodily awareness and capability to manipulate sounds, in order to acoustically achieve a musical idea, through gestures, movements and attitudes; (3) the influence that the physical properties of the instrument, as well as the environment acoustics, may have on sound control and production.

In the participants' view, the idea of touch and timbre goes well beyond a mere description of acoustical and physical-motor functions, including also references to the sensory sphere, as well as to historical/aesthetic/stylistic categories. The pianists provided an imaginative list of 209 descriptors, a large number of which was used to define touch (122), and a smaller number for timbre (87); in addition, some adjectives were used for representing both touch and timbre (26), as a demonstration of the blurred frames that usually enclose these concepts.

The analysis continued with the classification of descriptors into semantic categories (Tab. 1), reflecting the multiple layers of the concept of piano touch and the different levels of abstraction normally occurring in its appraisal.

Semantic Category	Description	Some Examples	Touch Adjectives	Timbre Adjectives
PHYSICAL-MOTOR	body parts and movements	<i>by arm, by finger tip, by curved finger, by shoulder, from a distance, from the key, percussive, quick, slow, vertical</i>	35	4
ARTICULATORY	musical phrasing (length of sound/key-depression, key-velocity attack and release, dynamic variation)	<i>legato, tenuto, marked, pizzicato, portato, staccato</i>	12	2
SENSORY	references to human senses, qualities, dimensions and spatial features of matter, chromatic/thermal synaesthesias	<i>bright, clear, deep, definite, delicate, dense, electric, fluid, hard, heavy, inactive, intense, light, misty, pearly, penetrating, plain, rigid, smoothed, soft, sweet, white</i>	38	64
EMOTIONAL	evocative images, feelings, sensations	<i>aggressive, brutal, dark, deep, energetic, ethereal, evocative, harmonious, magic, nervous, open, persuasive, powerful, relaxed, tender, violent</i>	17	14
AESTHETIC-STYLISTIC	formal/structural definitions linked to musical styles, traditional practices, authors, genres, instruments	<i>approximate, Bachian, baroque, "beautiful", cantabile, classical, controlled, elegant, expressive, jazz, modern, Mozartian, imitating other instruments, romantic, "ugly"</i>	25	12

Table 1. Semantic categories

According to the participants, it can be generally assumed that timbre and touch in piano performance are strictly related to each other, although not perfectly coinciding, and timbre seems to be conceived as “deriving” from touch. In greater detail, in this classification (Fig. 1) the touch descriptors are equally distributed among the five semantic categories, whereas the timbre descriptors exclusively figure into the sensory, emotional, aesthetic-stylistic categories, thus highlighting a strict connection on the one hand between the idea of touch and the physical aspects of musical performance, and on the other between the idea of timbre and sensory, emotional and aesthetic spheres. Moreover, in this classification, the central role of the sensory sphere seems to be strongly stressed: interestingly, in fact, the 26 descriptors commonly used by pianists to represent both timbre and touch were all placed in the sensory category, in between physical and cultural levels, as an ideal connection between the human senses and various aspects of matter (dimensional, spatial, chromatic and thermal). Such a complex outlook, as expressed by pianists, seems to suggest

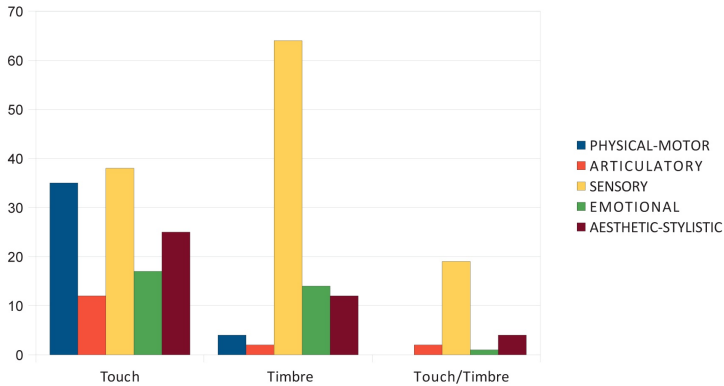


Figure 1. Adjectival semantic partition

that an exhaustive definition of piano touch may not exclusively be based on measuring physical parameters (key-velocity and articulation control), but that it conversely needs to consider a multi-layered taxonomy of descriptors, based on various levels of abstraction: a lower level linked to physical properties (cat. 1-2), a medium and more abstract level (cat. 3-4), and a very highly refined level (cat. 5) that rests on conceptual judgements derived from specific cultural backgrounds.

Musical Data Analysis

As regards the evaluation of the musical recordings, some precise touch parameters and nuances were extracted and quantified by measuring the onset/offset time between one key pressure and the subsequent one. Sound variations were captured in terms of: key velocity (KV), from a minimum value of 0 to a maximum of 127; temporal duration in beats per minute (BPM); the articulation interval between notes (A), where the value =1 expresses a standard *legato* (minimum onset interval in between notes), >1 a more *legato* effect (overlapping of subsequent notes), and <1 a less *legato* effect.

As the data clearly show, pianists are able to precisely control performance parameters in relation to the 5 different touch types. Nevertheless, such an ability to obtain a detailed and expressive piano

performance, by translating definitions of touch into different sound nuances through a subtle manipulation of the keys, seems to be rather instinctive, as pianists frequently appeared not to be overly precise in verbally explaining touch mechanisms in terms of KV and A control. As such, this research can help stimulate pianists' reflection on similar technical aspects, by confirming the validity of the analytical and technological instruments used, and leads to a more fluent transmission in pedagogical terms of specific knowledge concerning key control.

A comparison of the pianists' recordings allowed a high degree of agreement to emerge with respect to the influence that the 5 touch qualities have on key-parameters: significant relations were found, in particular, between the touch descriptors and changes in intensity (KV manipulation) and articulation (A), thus allowing KV and A to emerge as highly characteristic aspects of touch. Conversely, the lesser degree of concordance between speed and touch descriptors suggests that metronome variation (BPM) is not as representative of touch as KV and A. The table below (Tab. 2) gives a global view of the results of the 5 pianists' executions.

Recording Version	KV		A		BPM	
	AV	ST_D	AV	ST_D	AV	ST_D
<i>legato</i>	52	11	1,04	0,3	95	20
<i>light</i>	43	6	0,74	0,25	101	18
<i>soft</i>	49	8	0,95	0,2	94	18
<i>heavy</i>	77	5	0,92	0,2	96	18
<i>staccato</i>	63	11	0,31	0,17	111	12
<i>ad libitum</i>	58	10	0,92	0,32	95	18

KV 0/127 scale
A 1 = standard *legato*
 >1 = overlapping notes
 <1 = separated notes
BPM = beats per minute

Table 2. Total average and standard deviation of KV, A, BPM (KV: 0/127 scale; A: 1 = standard legato, >1 = overlapping notes, <1 = separated notes; BPM = beats per minute)

As the KV values provided here indicate, changes in intensity are apparently related to an idea of “weight”: the highest KV corresponds in fact to the heavy versions, and the lowest KV to the light

versions. Also, by comparing the descriptor-based performances (db) with the *ad libitum* one (al) (Fig. 2), the greater difference in KV manipulation occurs in the heavy and light performances.

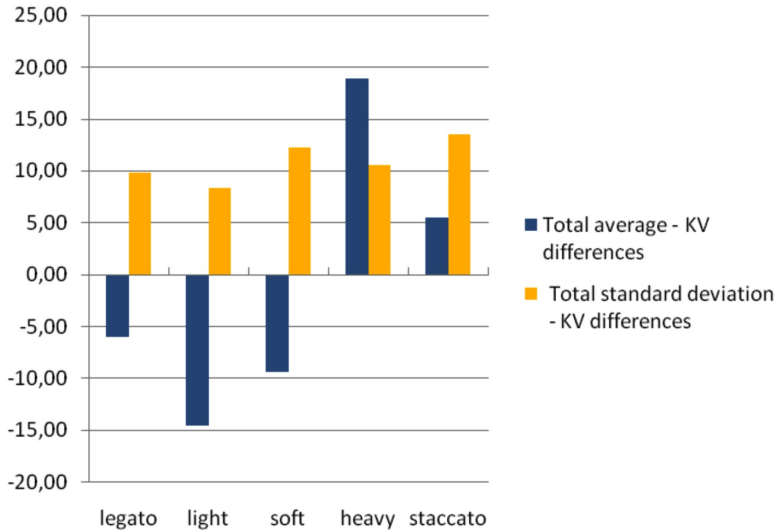


Figure 2. KV comparison between db / al versions

As regards articulation (A) (Fig. 3), the data show that pianists homogeneously used the greatest number of overlapping notes (average of 1,04) in order to obtain a legato, whereas the staccato execution logically present the lowest A value (0,31), and also appeared to diverge the most from the *ad libitum* one. However, any difference in A seems to emerge between heavy/*ad libitum* versions.

Lastly, looking at the temporal variations of the performances, as mentioned earlier a lower degree of concordance can be identified among pianists: any evident connection between touch-descriptors and tempo (BPM) emerges, thus suggesting that touch variations have a small influence on BPM, and that BPM may be not a very representative aspect of touch. However, from a comparison with the *ad libitum* version (Fig. 4), pianists seem to associate a fast tempo with the *staccato/light* descriptors, and a slow tempo with the *heavy/soft/legato* descriptors.

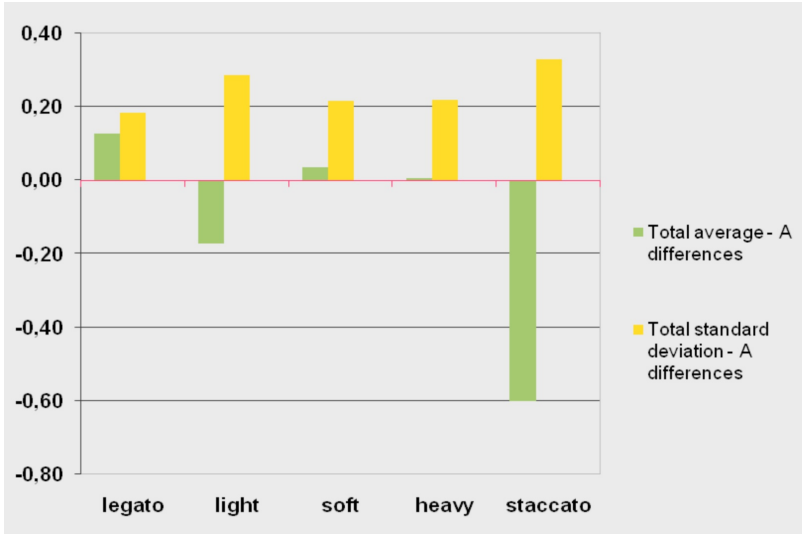


Figure 3. A comparison between db / al performances

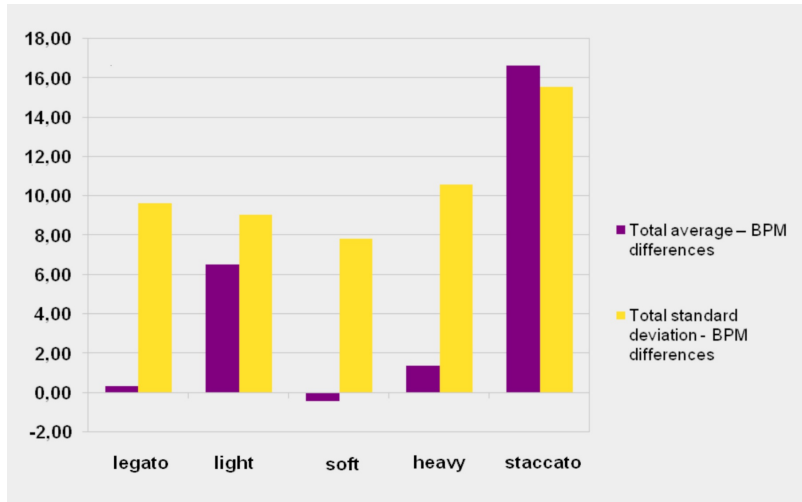


Figure 4. BPM comparison between db / al performance

Conclusion

While only representing the initial step of a longer investigative path in the analysis of expressive piano performance, this study provides encouraging results for a scientific description of touch and the relationship between touch and timbre. In order to avoid metaphorically based reflections, this research allowed plausible assumptions to emerge which may enable further theoretical developments; in its validation of specific technological systems of calculation, it also provided practical bases for further studies in this direction, as well as for pedagogical applications aimed at stimulating deeper reflection among pianists about key control.

On the basis of the data collected, a preliminary definition of touch may be hypothesized as a result of a more or less homogeneous interaction between three aspects of key control (KV, A, BPM). However, the touch/BPM relationship remains to be explored in greater detail. Although generally illuminating, in fact, these results still need to be integrated with more data, involving a larger number of pianists. Further considerations may also emerge in relation to the fact that touch parameters are not constant in a piano execution, since their course and nuances are modelled and adjusted according to the specific performer's intentions and his/her physiological, cultural and psychological condition at the moment.

Nevertheless, the personal modalities with which pianists combine touch parameters during performance may present some recurring features, as if responding to a sort of internal coherence, which make any performer's sound and attitude towards the instrument typical and unique, and which may allow one to distinguish each pianist's touch independently from its correspondence to any physical or aesthetic characteristics of music. However, although easily recognizable through an instinctive and qualitative approach, such a spontaneous combination of elements in modulating KV and A still needs to be clarified in quantitative terms.

Lastly, it could be assumed that an individuation and measurement of this kind of internal coherence in pianists' personal musical expression could provide a key that leads us towards a scientific understanding of touch, thus suggesting the development of a hypothetical paradigm

for a definition of touch and allowing for an exact description of the terms in which this complex and fascinating process of interaction between acoustic, physical and emotional elements takes place.

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