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Biases in the perception of dynamics in harpsichord performance

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ABSTRACT

It is widely claimed that it is not possible to vary dynamics on the harpsichord through touch; however, recent studies on single tones show that small dynamic differentiation can be obtained depending on the type of keypress. These differences are perceived accurately in comparisons of single tones; within a musical excerpt, they may be harder to detect, especially if biases exist. This study explores whether preconceptions regarding the ability of the harpsichord to produce dynamics influences perception of such differences. Two experiments are detailed: Experiment 1 uses two participant groups to test the effect of a bias (factor “cover story”) in the perception of two types of musical excerpt (factor “stimulus set”: dynamic variation performed/no dynamic variation performed). Experiment 2 adds a set of artificially manipulated excerpts to the stimuli, and presents all trials to participants in a fully within-groups design. Results of experiment 1 show a main effect of stimulus set (F (1, 30) = 24.01, p < .001). Experiment 2 results show a main effect of cover story (F (1,81) = 80.67, p < .001), and of stimulus set (F (2.30, 186.41) = 24.60, p < .001), with no interaction. The main effect of the stimulus set in both experiments demonstrates that it is possible to effect the perception of dynamics in musical excerpts. These results have implications for the understanding of historical performance practices.

I. INTRODUCTION

It is a generally received view that the harpsichord cannot produce any appreciable change in loudness (see, for example, the definition of harpsichord in the New Grove Dictionary of Music and Musicians: Ripin, Schott, & Koster, 2001).

Like all generally received views, it holds true, at least at some level; the harpsichord cannot indeed match the dynamic range of the lute, theorbo or harp. Furthermore, the desire to make the instrument capable of great dynamic contrast was already evident in the eighteenth century, with instrument makers inventing such devices as the “venetian swell”, or the *peau de buffle* register, which endowed the harpsichord with the capacity specifically to play crescendo and decrescendo (Hubbard, 1965).

However, it is possible to obtain small changes in volume between single tones on the harpsichord (Penttinen, 2006); recent studies have found evidence of intensity differences of up to 11 dB in the production of single tones on an anonymous historical instrument re-built by Taskin (MacRitchie & Nuti, 2015). The acoustic differences between single tones found in both Penttinen (2006) and MacRitchie and Nuti’s (2015) studies were accurately perceived by audiences.

Historical treatises (Couperin, 1717; Rameau, 1724; C. Ph. E. Bach, 1759, etc.) explain how to use an extensive and sophisticated range of performance techniques including varying timing between the hands, articulation, phrasing, arpeggiation, the speed of the spread of a chord and the overholding of notes, in order to enhance the listener’s experience of changes in loudness. The use of registration, on harpsichords with more than one register, further contributes to the variety of timbres and dynamics available on the instrument. Yet still, when asked directly, many listeners will say that the harpsichord is incapable of dynamic changes, even though it has been demonstrated how these techniques are able to effect such changes (Leonhardt, 2001).

Twentieth century schools of piano playing continue to contribute to this misunderstanding of an inability to realise the harpsichord’s capacities. Towards the end of the nineteenth century concern was already being expressed over an asserted limited responsiveness of the harpsichord: “Le son du clavecin n’était susceptible d’aucune modification de force ou de douceur par la pression des doigts” (Marmontel, 1885), “What we call *nuances* was unknown at the time of the harpsichord” (Saint-Saëns, 1895). This view of the instrument’s resources is understandable before the historical performance practice movement of the twentieth century; today, our increased knowledge of instrument construction, performance styles and performing techniques allows us to play the instrument, and its music, in a manner which is, arguably, closer to the performance intentions of the composers who wrote for the instruments they knew (Haynes, 2007).

Yet the belief that the harpsichord was somehow unsatisfactory took hold, with some performers going as far as to state – without much further explanation - that the composers that wrote for the harpsichord were also unhappy with the instrument: “It is common knowledge that the harpsichord, with its plucked tone, was regarded by musicians of that time as lacking in expressiveness” (Tureck, c. 1960).

The idea that the harpsichord cannot produce or create dynamics is still embraced by some modern pianists: “on the harpsichord…it’s all uniform” (Hewitt, 2008), “you simply cannot do that [play one note softer than another]” (Schiff, 2012). That harpsichord touch is unconnected to sound production is also sustained in contemporary literature: “No matter how hard a harpsichord’s keys are struck, the instrument’s quills pluck their assigned strings at a single, consistent volume, unleashing an unchanging, biting sonority” (Isacoff, 2001, p.9).

With such widespread conviction about the dynamic inability of the harpsichord, it is not surprising that it can be hard to convince people otherwise. It is well known that stereotypes or biases can influence people’s perception. For example, scholars in a wide range of scientific domains have shown that a given information can be perceived in different ways depending on its context (e. g. Bertrand & Mullainathan, 2004; Fichter & Jonas, 2008; Fernandez-Duque, Evans, Colton & Hodges, 2015). In the context of music it seems likely that the belief about an instrument can influence the way its sound is perceived. The question arises whether physically measurable dynamic differences in harpsichord music – such as produced on the Taskin harpsichord (MacRitchie & Nuti, 2015) – can be perceived when under the impression such differences do not exist. This set of experiments aimed to test the perception of dynamics in a context that allowed control of listeners' beliefs regarding the harpsichord's capacity to play dynamics.

II. Experiment 1

A. Method

1) Participants. Thirty-two participants (16 female, 16 male; age M = 21.97, SD = 2.42 years) from the Conservatorio della Svizzera Italiana took part in this study. Participants had M = 12.97, SD = 4.68 years of musical experience. Participants were in two groups, assigned by music class.

Group 1 comprised 15 participants (undergraduate students of a history of music class; 5 female, 10 male; age: M = 20.73, SD = 2.63; experience: M = 9.87 years, SD = 3.72) and group 2 comprised 17 participants (undergraduate and postgraduate students of a seminar on historical performance practice; 11 female, 6 male; age: M = 23.13, SD = 1.58; experience: M = 15.88 years, SD = 3.50). The two groups significantly differed in terms of age ($t(29) = 3.04$, $p = .005$) and musical experience ($t(29) = 4.63$, $p < .001$), group 2 being older and more experienced. They did not differ in their practical experience with harpsichords, $\chi^2(1, N = 32) = 0.23$, $p = .29$.

2) Materials. Twelve excerpts of harpsichord music of approximately 10-12 seconds duration were selected from recordings of full pieces of music (Nuti, 2014). These excerpts were performed by co-author Giulia Nuti, on an anonymous 18th century harpsichord, extensively revised by Pascal Taskin in 1788. At recordings, the microphone was at a distance of approximately 1m from the harpsichord's quills. Six of the excerpts were performed using differences in touch and techniques intended to create dynamic variation (set B), the other six were performed without intention of producing dynamic variety, so techniques normally used to produce dynamic variation were not used specifically (set A). In order to check if the two sets were comparable in terms of overall dynamic structure (i. e. dynamic variation due to high vs. low notes, number of notes per time unit, etc.), intensity measures were calculated for each excerpt using Praat (http://praat.org), with the coefficient of variation used to compare variation in intensity between each set of excerpts. An independent samples t-test confirmed no significant differences between the variations in intensity of set A versus B, indicating that the two sets were comparable. However, the dynamic variation achieved between single notes through the use of touch technique alone could not be objectively measured from the audio recordings in isolation from other simultaneous notes.

3) Design and Procedure. For each group, data collection took place in the students' regular classrooms in one session, at the end of a lecture. Participants gave their consent and were advised they could abort the experiment at any time, discarding their data. The excerpts were played through a central state-of-the-art loudspeaker system.

The two groups were tested in a between-subjects design for the factor of bias (hereafter referred to as cover story): Group 1 (n = 15) was told that it is possible to measure dynamic variation on single tones, the *peau de buffle* register of French harpsichords being particularly sensitive to touch (cover story "Expect Variation"); group 2 (n = 17) was told that it is not possible to achieve dynamic variation through touch, and that any change of loudness they might perceive was not because of actual physical decibel changes, but due to techniques employed by harpsichordists to convey the impression of dynamic variety, such as timing, articulation, etc. (cover story "Expect Uniformity"). After instruction, each group was presented the 12 excerpts of harpsichord music in a pre-defined, randomised order. This order was the same for both groups. Using a 2-alternative forced choice paradigm, participants were asked if they could hear dynamic variety. Participants indicated their responses on paper for each excerpt.

B. Results and Discussion

Data was analysed based on the rate of "dynamics present" answers for each set of musical excerpt. Results are displayed in Figure 1. A two-way ANOVA (factors "cover story" and "stimulus set") revealed a significant effect of stimulus set, $F(1, 30) = 24.01$, $p < .001$, $\eta^2 = .44$. No effect of cover story was found, $F(1, 30) = 0.005$, $p = .94$, $\eta^2 = .00$, and no interaction, $F(1, 30) = 1.47$, $p = .23$, $\eta^2 = .04$. The cover story had no significant effect on the signal detection measure d', $t(30) = 1.21$, $p = .24$, which is in line with the ANOVA. Neither did the cover story significantly influence the criterion C, $t(30) = 0.64$, $p = .52$.

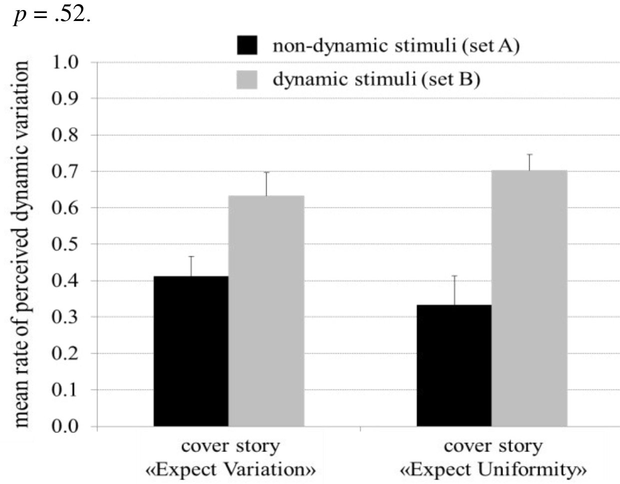

Figure 1. Rate of perceived dynamic variation in Experiment 1. Error bars represent standard errors of means.

These results indicate that it is possible to perceive intended dynamic variation on a harpsichord. Participants could significantly distinguish between excerpts that included dynamic variation and those that did not. However, there is a possible methodological caveat: The stimuli of sets A and B were chosen by the artist on the basis of how she had intended to perform them (i. e., using touch variation for set B, none for set A), and not based on the measurement of any physical parameters. As stated in the introduction section, there are a variety of performance techniques that enhance the listener's experience of changes in loudness, by varying the timing of note onsets and offsets (e. g., spreading of chords, articulation, phrasing etc.). As there is no way of accurately determining the intensity of each single note performed within a polyphonic excerpt, it remains unclear whether the dynamic variation perceived in set B derived from an actual physical change of decibels, or whether the performance techniques simply influenced loudness perception. Data from the single tones studies (Penttinen, 2006; MacRitchie and Nuti, 2015) would suggest that physical differences may exist.

No main effect of cover story was found in the rates of perceived dynamic variation. This is unexpected when considering the literature on the effect of biases and stereotypes. One explanation for this lack of effect may be that the cover stories were not convincing enough. Cover story "Expect Uniformity" was intended to evoke expectations of hearing music that was completely free of dynamics. Although it was mentioned in this story that no dynamic variation was possible on a harpsichord, the story still included a remark on those alternative techniques used to convey the impression of dynamic variety. This may have spoiled the expectation of hearing music without dynamics. Furthermore, although the two groups' reported experience with the harpsichord instrument was equivalent, the two participant groups differed significantly in terms of age and musical experience. We cannot be sure that the difference between groups was not effected by these variables.

Experiment 2 was thus conducted with three modifications: First, a within-subjects design was used rather than a between-subjects design. Second, the cover story "Expect Uniformity" was modified to be more effective. Third, in addition to the A and B stimuli, a new set of artificial stimuli was created to allow a more detailed analysis of the nature of dynamical variance within the full stimuli set.

III. Experiment 2

C. Method

1) Participants. Ninety-one participants (62 female, 29 male; age M = 26.81, SD = 6.66 years) of the University of Zürich, including both post-graduate students and academics took part in this experiment. Nine participants were excluded from data analysis due to missing data, leaving a total of 82 participants for data analysis. Out of those, six considered themselves not interested in music at all; 53 as interested and not playing an instrument; 20 as interested and playing an instrument (M = 13.75, SD = 9.02 years of experience), and three as professional musicians (M = 24.67, SD = 9.07 years of experience).

2) Materials. The sets of stimuli used in experiment 1 (sets A and B) were also used in experiment 2. In addition, two parallel sets were created, adding dynamic variability artificially (sets A' and B'). The sets were created using Audacity software (http://web.audacityteam.org). Three types of variation were added, according to the dynamic variations reported by the performer as occurring in the B set. Crescendo and decrescendo were applied one per excerpt. These were created by modifying the original volume by +/- 3 dB (which is the approximately the degree of intensity variation obtainable on all registers by using different touches, measured on single tones on this instrument, see MacRitchie & Nuti, 2015). Sforzandi were applied where musically plausible, by augmenting the volume by 1.5 dB in the accented sforzando notes, and reducing by 1.5dB in the unaccented notes immediately following the sforzandi. In the B-set, the modifications were applied in such a way as to enhance the dynamics reported as already present in the excerpt; in the A-set, dynamic contrast was added where it was most musically appropriate.

Due to the increased number of stimulus sets (four instead of two), the number of excerpts per set was reduced from six to four. For this, the ratio of correct answers in experiment 1 was calculated for sets A and B, and the two stimuli with least discriminability were excluded from each set (also from sets A' and B', accordingly), resulting in a total of 16 stimuli used in experiment 2.

3) Design and Procedure. Data collection took place in a classroom in one session, as part of a regular colloquium (within-subjects design). The excerpts were played through a central state-of-the-art loudspeaker system. As the room was large, audibility was tested at various locations of the room prior to the experiment.

The cover story condition "Expect Variation" was followed by the "Expect Uniformity" condition. Each block was preceded by verbal instruction and data was collected from participants' responses on paper. The text of cover story "Expect Variation" was the same as in experiment 1. Since cover story "Expect Uniformity" was considered unsuitable to evoke expectations of non-dynamics, it was modified for experiment 2: After having completed the first condition, the participants were told that the previous experiments were actually part of a larger study on the perception of harpsichord music. One experiment asked for the use of completely non-dynamic stimuli as a baseline. For this, the same stimuli they had just heard were modified artificially to be bare of any dynamic variation. But since, as they surely knew, human perception did not always match the underlying physical parameters, it was necessary to pre-test these stimuli for their impression of dynamic flatness before using them in the actual experiment. The class was therefore asked to listen to the excerpts in order to check if all the stimuli were now truly without dynamics.

The stimuli were presented in a pre-defined randomised order (the order was kept the same for both cover story

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conditions), with the restriction that the corresponding excerpts of any set could not be presented consecutively (e.g. excerpt 1 from set B' could not be presented following excerpt 1 from set B).

D. Results and discussion

The participants' musical experience (professional, interested and playing an instrument, interested without playing, not interested in music at all) had no significant effect on *d'*, $F(3, 78) = 2.45$, $p = .07$ (one-way ANOVA). Also, for those who did play an instrument, there was no significant correlation between *d'* and years of experience, $r(17) = .17$, $p = .40$. The sample is therefore considered homogenous.

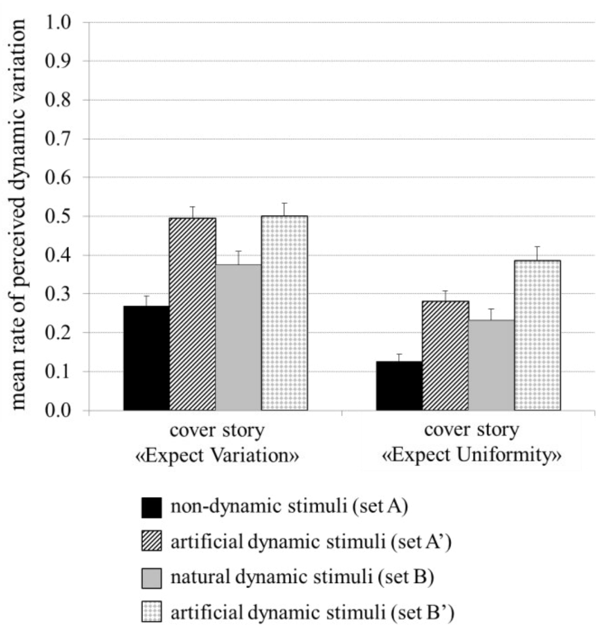

Figure 2. Mean rate of perceived dynamic variation in Experiment 2. Error bars represent standard errors of means.

Results are shown in Figure 2. As in experiment 1, data analysis was based on the rate of "dynamics present" answers for each stimulus set. Generally, the mean rates are lower in experiment 2 than experiment 1, which may be explained by differences in musical experience between the two samples. A two-way ANOVA (factors "cover story" and "stimulus set") revealed a significant effect of stimulus set, $F(2.30, 186.41) = 24.60$, $p < .001$, $\eta^2 = .23$; and of cover story, $F(1, 81) = 80.67$, $p < .001$, $\eta^2 = .50$. The interaction was not significant, $F(2.79, 266.45) = 1.81$, $p = .15$, $\eta^2 = .02$.

Table 1. Results of t test comparisons conducted on the mean rate of perceived dynamic variation between stimuli sets, separated by cover story. Holm corrections are applied to the results. Holm corrections are applied to the results.

cover story "Expect Variation"		
sets compared	***t* value (*df* = 81)**	***p* value**
A – B	6.00	= .049
A – A'	3.03	< .001
A – B'	6.15	< .001
A' – B	2.58	n.s.
A' – B'	0.14	n.s.
B – B'	3.43	= .01
cover story "Expect Uniformity"		
sets compared	***t* value (*df* = 81)**	***p* value**
A – B	3.50	= .007
A – A'	4.74	< .001
A – B'	6.75	< .001
A' – B	1.20	n.s.
A' – B'	2.46	n.s.
B – B'	5.23	< .001

Effects of stimulus sets: Single comparisons are displayed in Table 1. For both cover stories, set B was perceived as containing significantly more dynamic variation than set A, confirming the results of experiment 1. This finding indicates that volume changes in harpsichord music due to the use of different touches can be heard. The difference in responses to the natural and artificial sets (A versus A', and B versus B') was also significant for both cover stories. For both cover stories, the artificial set A' did not differ from the natural set B, indicating that the artificial manipulations administered in set A' were comparable to the natural dynamic variations achieved through touch in set B. The largest difference in response between two sets was found between sets A and B', set B' receiving the highest ratings of "dynamics present". This confirms the internal logic of the four stimulus sets, as B' contained both natural (achieved through touch) and artificial changes of loudness.

Table 2. Results of t test comparisons conducted on the mean rate of perceived dynamic variation between cover story conditions, separated by stimulus sets. Holm corrections are applied to the results.

cover story "Expect Variation" versus "Expect Uniformity"		
sets compared	***t* value (*df* = 81)**	***p* value**
A	4.70	< .001
B	7.60	< .001
A'	3.31	< .001
B'	3.99	= .001

Effects of cover story: Single comparisons are displayed in Table 2. For all stimulus sets, the two cover stories had a significant influence on perceived dynamic variation, cover story “Expect Variation” evoking higher rates of perceived dynamic variation than cover story “Expect Uniformity”.

IV. CONCLUSION

The set of experiments presented in this paper demonstrate that the harpsichord is capable of producing perceivable changes in dynamics through differences in touch technique. That those changes can be perceived within musical excerpts suggests that acoustic differences achieved through touch technique on single tones may have an application in the performance of polyphonic music. It was also shown in this study that perception is influenced by bias: When under the impression to hear non-dynamic music, the rate of perceived changes of loudness was lower than when expecting to hear dynamic variation. How these touch techniques are used by harpsichordists to effect physical and perceived dynamic variation, and how these biases can be eventually reduced, warrants further investigation.

There are methodological restrictions to be considered in this study: First, the classical research paradigm for perceptual studies would have been to do single testing under controlled conditions, and not, as was done here, collective testing in a classroom. However, while results obtained from single testing might be more significant from the point of view of perception, the setting chosen here was of higher ecological validity. Second, in both experiments, musical experience of the participants was not controlled. Even though musical experience did not significantly influence *d’* in experiment 2, such effects cannot be ruled out generally, as sample sizes for each category (professional, interested and playing an instrument, interested without playing, not interested in music at all) were far from homogenous. The results obtained in this study suggest that the ability for dynamic perception rises with increased expertise (mean rates of perceived dynamic variation being higher in experiment 1 than 2). More research is needed to assess the role of expertise on dynamic perception and possible biases. Third, as the presentation order of stimuli (experiments 1 and 2) and of cover story (experiment 2) was held constant, effects of presentation order cannot be ruled out. Finally, the sets of stimuli used in this study were small, and the dynamic manipulations administered to sets A’ and B’ (crescendo, decrescendo, sforzando) were not varied systematically across stimulus sets, but rather placed where musically plausible. To confirm the effects found in this study, more research is needed controlling for artificial manipulation across excerpts.

Despite these restrictions, this study suggests two principal effects: that dynamic variation in harpsichord music is perceptible to the human ear, and that this perception is subject to biases. These findings indicate that widespread beliefs about the harpsichord’s capabilities have been playing a part in dampening perception of this particular performance trait. Although it is acknowledged that these dynamic differences are far from being on a par with those of other plucked string instruments such as the harp, or indeed other keyboard instruments such as the piano to which it is invariably compared, it is still vital to performance practice to understand the full capabilities of an instrument long regarded to only be able to afford the performer a uniform response.

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