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Optical channel patterns during preparation and performance of scored and improvised music in an exploratory fNIRS study

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Article

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Abstract

Preparing to play may set up processes that carry over into the performance itself, but whether the two phases correspond probably depends on the task and on the signal being measured. In a secondary analysis of 24 musicians, we compared preparation and performance across 15 optical channels in three tasks: score-based reproduction, constrained variation and free improvisation. For each phase, mean baseline-subtracted RAW d780 amplitude was computed over a matched 20-s interval starting 5 s after onset, and the two 15-channel vectors were compared by Pearson correlation. Median correlations were 0.575, 0.631 and 0.389, and coefficients were positive in 17, 20 and 18 participants, respectively. After Holm correction, exploratory exact sign tests remained significant for constrained variation ($P = 0.0046$) and free improvisation ($P = 0.0453$) but not for score-based reproduction ($P = 0.0639$). No paired between-task comparison survived correction, nor did any of the 45 channelwise phase-amplitude contrasts. Ten participants were positive in all three tasks. Optical channel patterns therefore corresponded across the two phases, without evidence of task-specific differences or neural equivalence. As no hemoglobin conversion, motion correction or physiological-signal regression was applied, the cortical origin of this correspondence is unresolved.

Introduction

Musicians prepare actions whose timing, sensory consequences and expressive aims only unfold once they begin to play. This relation matters most in improvisation, where some musical decisions are settled before playing and others are made in the moment. Neuroimaging work has compared improvised performance with the production of familiar or prescribed material. Rather than a uniform shift across frontal regions, these studies report differentiated prefrontal responses, and they point to musical experience as one likely source of variability [1, 2]. Functional near-infrared spectroscopy (fNIRS) has also been applied to prefrontal responses during live guitar improvisation [3]. Taken together, this work suggests that the way signals are organized across measurement sites deserves attention alongside the usual comparisons of response magnitude.

A different question is how the preparatory period relates to the performance that follows it. Earlier piano studies compared performance conditions and related them to subjective measures [4], or used an autoencoder to contrast score-based performance with motif improvisation in piano-major and non-piano-major musicians [5]. The present analysis draws on the same experimental cohort as that autoencoder study and on the group experiment reported in Kang's doctoral dissertation [6]. What it adds is a within-participant comparison between preparation and the subsequent performance in each of three musical tasks. Put simply, we asked whether channels with relatively large baseline-subtracted values during preparation also tend to show relatively large values while the participant is playing.

Studies of explicitly instructed musical imagery give one reason to expect a link between covert preparation and overt action. In functional magnetic resonance imaging experiments with pianists and violinists, imagery and execution evoked responses that were partly shared and partly distinct [7, 8], and

multichannel near-infrared recordings show that imagined and executed movements can differ in their spatial and temporal response profiles [9]. Preparation, however, covers more ground than imagery. Within a single preparatory period a musician may read a score, work out a variation, anticipate an instruction or plan movements. We therefore use the operational term preparation and do not assume that this interval isolates an imagery process common to all conditions.

Correspondence between optical channels has to be interpreted with care. fNIRS instruments record light measurements from which changes in hemoglobin concentration can be estimated, provided that acquisition and processing are documented [10]. Raw optical amplitude, by contrast, still carries the influence of measurement sensitivity and extracerebral physiology. Task-related systemic responses are known to contribute to superficial signals [11], and global and local signal components can differ in spatial structure across channels [12]. A positive correlation between raw channel patterns is therefore not, on its own, evidence of shared cortical activity. How the signal was scaled and processed has to remain part of the interpretation.

Here we analyzed preparation and performance in 24 musicians with data for three tasks: score-based reproduction, constrained variation of a short motif and free improvisation. Both phases were analyzed over matched 20-s intervals, each with its own resting baseline. For every participant and task, we correlated two 15-channel vectors of mean RAW d780 amplitude, one from preparation and one from performance, and took the distribution of these channel-pattern correlations as the main descriptive endpoint. We also compared the correlations between tasks and asked whether mean amplitude in individual channels differed between the two phases. The study was exploratory; the sign tests for an excess of positive correlations, in particular, were added after the data had been inspected. Our aim was to quantify the observed relation and its uncertainty while keeping optical correspondence separate from claims about neural equivalence or the content of imagery. Figure 1 outlines the analysis workflow.

Results

Analytic sample and channel pattern correspondence

Twenty-four participants had recordings for all three tasks and formed the common analytic sample. Of the other two, one lacked the relevant Excel recording file and the other had data for free improvisation only. The sample included musicians with piano and non-piano backgrounds. Each participant contributed one preparation–performance correlation per task, giving 72 participant-by-task coefficients, but the participant remained the independent unit of inference. Table 1 defines the tasks.

Table 1
Musical tasks and preparatory activities

Task	Preparation	Performance
A Scored reproduction	Read the score of Clementi's Sonatina Op. 36, No. 3, first movement	Perform according to the score
B Constrained variation	Read the opening two-bar motif and plan a constrained variation	Perform a variation under the task constraints
C Free improvisation	Rehearse mentally without a score	Improvise freely

Preparation is an operational phase label, and its visual and cognitive demands differ between tasks. In all three tasks, the main analysis used the same phase-relative interval ($5 \le t < 25$ s) for preparation and performance.

Median Pearson correlations between the preparation and performance channel patterns were 0.575 in score-based reproduction (A), 0.631 in constrained variation (B) and 0.389 in free improvisation (C). The participant-bootstrap 95% confidence intervals for these medians were [0.124, 0.727], [0.470, 0.808] and [0.232, 0.606], and the median Spearman correlations were 0.436, 0.459 and 0.325. Central tendencies were thus positive in all three tasks, although participants varied considerably (Table 2; Fig. 2). Each bootstrap interval refers to a single task and is not a simultaneous confidence interval.

Table 2
Preparation and performance channel pattern correlations

Task	Median Pearson r	95% CI of median	Median Spearman ρ	Positive / negative	Holm-adjusted P
A	0.575	0.124–0.727	0.436	17 / 7	0.0639
B	0.631	0.470–0.808	0.459	20 / 4	0.0046
C	0.389	0.232–0.606	0.325	18 / 6	0.0453

n = 24 for each task. Pearson r and Spearman ρ compare two 15-channel vectors of mean baseline-subtracted RAW d780 amplitude from matched 20-s intervals. Confidence intervals come from 10,000 participant bootstrap resamples and are not simultaneous. P values are from exploratory two-sided exact sign tests against equal probabilities of positive and negative correlations, Holm-adjusted across the three tasks; they do not test between-task differences.

Correlations were positive in 17 of 24 participants for A, 20 of 24 for B and 18 of 24 for C. We tested these counts against equal probabilities of positive and negative signs with exploratory two-sided exact sign tests. Holm-adjusted P values were 0.0639, 0.0046 and 0.0453, so the excess of positive coefficients held after correction for B and C, but not for A. These tests address how often coefficients were positive. They do not test whether any single participant's correlation was significant.

Comparison of correlations between tasks

Paired comparisons of Fisher-z-transformed coefficients gave mean differences of 0.161 for B minus A ($P = 0.4910$; BH-adjusted $P = 0.7365$), − 0.060 for C minus A ($P = 0.7595$; adjusted $P = 0.7595$) and − 0.221 for C minus B ($P = 0.2472$; adjusted $P = 0.7365$). B had the highest median, then, but the paired analysis gave no evidence that correspondence differed between tasks. Likewise, a significant sign test in B and C alongside a nonsignificant one in A does not by itself amount to a difference between those tasks.

Variation across participants

Ten participants had positive correlations in all three tasks, 11 in exactly two and three in only one. No participant was negative in all three. Every individual coefficient is shown in Fig. 3 and listed in Supplementary Table S1. With one recording per task, these patterns describe variability within the present data and say nothing about stable participant traits or reproducibility across sessions.

Of the 10 participants who were positive in every task, two (participants 7 and 23) had $r \geq 0.5$ in all three. Among the 11 with exactly two positive tasks, three were positive for A and B, three for A and C, and five for B and C. Within these groups, $r \geq 0.5$ in both positive tasks was reached by participants 6, 13 and 15 (A–B), participant 26 (A–C) and participant 4 (B–C). The complete classification is given in Supplementary Table S1; these are descriptive groupings, not validated subgroups.

Amplitude contrasts and dependence on the analysis interval

In the matched 20-s analysis, none of the 45 channelwise performance-minus-preparation contrasts in mean amplitude remained significant after BH correction (Supplementary Table S2). This null result should not be read as evidence that amplitudes were equal.

The supplementary analyses were likewise nonsignificant after correction, with one exception. In the full-phase analysis, which compared phases of unequal length, task A channels 6, 8 and 12 each had a BH-adjusted P of 0.0397. Because this result depends on the choice of interval, we treat it as secondary to the matched-window findings (Supplementary Tables S3–S6).

Discussion

In this exploratory study, channel patterns recorded during musical preparation corresponded mostly positively with those recorded during the performance that followed. Across 24 musicians, median correlations were positive under all three task constraints, and the excess of positive over negative coefficients survived correction for constrained variation and free improvisation. Ten participants were positive in every task. Direct comparisons, however, did not show that correspondence differed between tasks, and no matched-window channelwise amplitude contrast survived correction. The findings are best described as a pattern-level relation in baseline-subtracted optical recordings whose physiological specificity is still unknown.

A Pearson coefficient captures whether channels with relatively high preparation values also have relatively high performance values. It is unaffected by a uniform offset or a positive rescaling, so pattern correspondence does not imply equal amplitude. And because the endpoint compares channel means rather than aligned time courses, it cannot speak to temporal synchronization, functional connectivity or identical musical thoughts.

Constrained variation yielded the highest median correlation, yet the paired comparisons did not separate it from the other tasks. Sign tests describe how prevalent positive coefficients are; they cannot show that correspondence was stronger in one task than in another. On this evidence, ranking the tasks by an effect of creativity or musical constraint is not warranted.

This secondary analysis complements earlier work on improvisation [1–6] and extends the autoencoder analysis of the same cohort [5] to preparation–performance correspondence. It is not an independent replication. Research on musical imagery offers a rationale for comparing covert and overt performance [7, 8], but the visual and cognitive demands of preparation differed between our tasks. The correspondence we observed therefore cannot be attributed specifically to imagery.

The main measurement limitation is that we analyzed RAW d780 amplitude rather than estimated hemoglobin concentrations. Baseline subtraction neither calibrates channel sensitivity nor removes channel-dependent contributions from motion or from shared systemic and extracerebral physiology [10–13], so channel-pattern correspondence cannot be assigned specifically to cortical activity. The design imposes a second constraint. Preparation always came before performance, which leaves elapsed time, carryover and the timing of physiological responses confounded with phase [9, 14]. Baselines were taken from the final 5 s of the preceding marked rest interval, and any gap between that rest and the next phase was retained. With a small sample and a single recording per task, precision is limited, and neither equivalence nor test–retest reliability can be established. Finally, the $r \geq 0.5$ threshold summarizes the observed coefficients and is not a validated way of classifying participants.

In conclusion, optical channel patterns during preparation and performance generally corresponded positively in all three musical tasks, although the strength and consistency of this correspondence varied between participants. We found no evidence that it differed between tasks. These results characterize the preparation–performance relation in the present recordings; whether that relation is cortical in origin, or specific to particular tasks, remains to be established.

Methods

Study design and participants

We conducted an exploratory secondary analysis of existing recordings from the cohort described by Kang et al. [5] and in Experiment II of Kang’s doctoral dissertation [6]. For the original experiment, 26 musicians were recruited through announcements in academic and professional music networks, including music colleges and professional societies. Recordings were made in a studio in Seoul,

Republic of Korea, in 2023 [6]. Participants completed score-based reproduction (A), constrained variation (B) and free improvisation (C).

The common analytic sample comprised the 24 participants with preparation and performance data for all three tasks. Study code 5 was excluded because the relevant Excel recording file was unavailable, and study code 16 because only task C data were available. Both piano and non-piano backgrounds were represented. Sample size was determined by the number of complete three-task recordings available.

The earlier PLOS ONE report used an LSTM autoencoder to compare 22 piano-major and non-piano-major musicians [5]. The present analysis uses a 24-participant set selected for the three-task preparation–performance comparison and does not use the autoencoder endpoint. Because both analyses draw on the same original cohort, the present results extend that dataset rather than replicate it independently.

Ethics approval and informed consent

The original study protocol was approved by the Institutional Review Board of Chungbuk National University (CBNU-202302-HR-0038; amendment CBNU-202303-HR-0057). Participants were informed about the aims of the study, the experimental procedures and any discomfort the equipment might cause, and written informed consent was obtained from all of them [6]. All methods were performed in accordance with the relevant guidelines and regulations, including the Declaration of Helsinki.

Musical tasks and phase definitions

Three days before testing, participants received the score of the first movement of Muzio Clementi's Sonatina in C major, Op. 36, No. 3, and were asked to become familiar with it without memorizing it. A 60-minute workshop introduced basic improvisational skills [6]. In task A, participants prepared by reading this score and then performed it as notated. In task B, the opening two bars served as a motif from which they planned and then performed a constrained variation. In task C, they rehearsed mentally without a score and then improvised freely. Table 1 summarizes the preparatory activity in each task.

Each participant completed A, B and C once, in a randomly assigned order [6]. Within each task, the nominal sequence was 30 s of rest, 30 s of preparation, 10 s of rest, 60 s of performance and 30 s of rest. A score was available during preparation in A and B, whereas preparation in C was mental rehearsal without a score. An eight-beat metronome cue preceded performance [6]. Task order was randomized, but the order of phases was not: preparation came before performance in every task.

Participants played an 88-key YAMAHA P125 keyboard and heard their playing through speakers. They were asked to keep head movement to a minimum and to look straight ahead, and the score remained in view for A and B. MIDI performances were recorded concurrently using Logic software [6]. For the optical analysis, phase boundaries were identified separately in each recording. In both preparation and performance, the main interval began 5 s after the respective onset and ended before 25 s after onset.

Optical recording and analyzed signal

Optical signals were recorded from 15 prefrontal channels with the NIRSIT LITE system (OBELAB, Seoul, Republic of Korea) [5, 6]. Staff fitted the device to the forehead while avoiding hair, and calibration was performed for each session [6]. The system uses continuous-wave illumination at 780 and 850 nm. The manufacturer specifies a scan rate of up to 8.138 Hz [15], whereas the previous report described acquisition at 8 Hz [5]. We analyzed the 15-channel export labelled RAW d780 amplitude, expressed in arbitrary units.

The earlier publication described HbO/HbR measurements with real-time processing in OBELAB's proprietary software [5]. Here, by contrast, we used the RAW d780 exports and did not treat those values as hemoglobin concentrations. After export, processing was limited to baseline subtraction, interpolation and interval averaging. No optical-density conversion, HbO/HbR conversion, motion correction or physiological-signal regression was applied, and the statistical comparisons did not rely on anatomical attribution of individual channel numbers.

Baseline subtraction and matched intervals

For each participant, task, phase and channel, the baseline was the mean amplitude over the final 5 s of the preceding marked rest interval (rest-end minus 5 s ≤ time < rest-end). Preparation and performance had separate baselines, and any gap between a marked rest and the following phase was retained. Each phase was linearly interpolated onto 163 samples at 0.12288-s intervals within $5 \le t < 25$ s of phase onset. The extraction code checked that the exported timestamps had this spacing, although regular exported intervals do not rule out undocumented processing inside the device. The channel-specific baseline was then subtracted and the corrected samples were averaged.

This gave one pair of 15-channel mean vectors per participant and task. Participants, not channels or interpolated samples, were the independent units. Input validation, phase-selection rules and the handling of invalid values are described in the Supplementary methods. No further channel rejection or motion-based exclusion was applied, and all 72 saved Pearson coefficients were finite.

Channel pattern correspondence

For each participant and task, Pearson r was calculated across the 15 paired channel means from preparation and performance. With p denoting the vector of preparation means and e the vector of performance means, the endpoint is corr(p, e), where each pair of entries refers to the same measurement channel. A positive coefficient indicates similar relative channel patterns but does not require identical amplitudes. Spearman rank correlation between the same vectors served as a secondary descriptive measure.

For each task we summarized the median Pearson correlation, its participant-bootstrap 95% confidence interval and the numbers of positive and negative coefficients, together with the median Spearman correlation. Participant-level coefficients were kept as continuous values in the main analysis.

Statistical inference and multiplicity

All inferential tests were two-sided, with the participant as the independent unit. Confidence intervals for median correlations were obtained from 10,000 participant bootstrap resamples. Within each task, the number of positive correlations was tested against equal probabilities of positive and negative signs with an exact sign test, and the three P values were adjusted with the Holm procedure [16]. This test was added after inspection of the data, so we report it as exploratory. All 24 coefficients in each task were nonzero. Significance was assessed at $\alpha = 0.05$ after the stated correction. The sign test concerns how prevalent positive signs are; it is not a physiological null model of task-specific correspondence.

For the paired comparisons of A with B, A with C and B with C, correlations were first Fisher z-transformed and then compared with participant-level two-sided sign-flip tests using 100,000 resamples. Sign-flip inference assumes that participant-level differences are symmetric under the null hypothesis [17]. BH adjustment was applied to the family of three task contrasts [18]. Both the transformation and the resampling preserved the paired structure, so observations from different tasks in the same person were never treated as independent.

For the amplitude comparisons, the baseline-subtracted preparation mean was subtracted from the performance mean separately for each participant, task and channel. These differences were assessed with two-sided sign-flip tests (100,000 resamples), and participant bootstrap confidence intervals were based on 10,000 resamples. In the matched-window analysis, BH correction was applied across all 45 task-by-channel comparisons, with the false discovery rate set at 0.05. The confidence intervals reported are pointwise and not adjusted for multiplicity. All resampling analyses used the random seed 20261018.

The sign-flip statistic was the mean paired difference, and two-sided Monte Carlo P values were calculated as $(b + 1)/(100{,}000 + 1)$. Bootstrap intervals were taken from the 2.5th and 97.5th percentiles of the participant resamples. Full resampling specifications appear in the Supplementary methods. Confidence intervals for the task contrasts were not generated in the original analysis.

Exploratory descriptive and interval analyses

Participants were grouped according to whether their Pearson correlations were positive in three, two or one task. Within the groups with two or three positive tasks, we also counted participants whose r was at least 0.5 in every positive task, using the unrounded coefficients from the original analysis. This threshold is an explanatory convention, not a validated cutoff or a test of individual significance.

The existing supplementary analyses examined full-phase means, matched-window standard deviations and medians, and between-task differences in phase-related mean changes. Each formed a separate BH family of 45 tests. Definitions and complete results are given in the Supplementary methods and Supplementary Tables S3–S6.

Code availability

Extraction and analysis were implemented in prepare_phase_comparison.py and analyze_phase_comparison.py, and participant sign-test results were stored separately. The numerical outputs used in this manuscript are saved in results.json and similarity_sign_test.json, with phase-extraction metadata in segments.json. The scripts specify 100,000 sign flips, 10,000 bootstrap resamples and seed 20261018. The analysis code is available from the corresponding authors on reasonable request.

Use of generative artificial intelligence

ChatGPT (OpenAI; accessed 18–19 October 2026) assisted with drafting and revising the manuscript, identifying literature, formatting existing results, preparing figures and drafting responses to editorial comments. Claude (Anthropic; accessed 21 October 2026) was used for language editing of the final text. All revisions were based on saved statistical outputs, and no additional inferential analyses were performed. The authors verified all sources, numerical results and the final text, and take full responsibility for the content of the manuscript.

Data availability

Participant-level coefficients and detailed statistical results are provided in the Supplementary information (Supplementary Tables S1–S6). The raw optical recordings are not publicly available to protect participant privacy but are available from the corresponding authors on reasonable request.

Declarations

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Competing interests

The authors declare no competing interests.

Author Contribution

H.J.K. conceived and designed the original experiment, collected the data, contributed to the interpretation of the results, and wrote the Introduction and Discussion. K.M.P. developed the methodology for the present analysis, processed and analyzed the data, and prepared the figures. Both authors contributed to drafting and revising the manuscript and approved the final version.

Data Availability

Participant-level correlation coefficients and detailed statistical results are provided in the Supplementary Information accompanying this article (Supplementary Tables S1–S6). The raw optical recordings are not publicly available due to participant privacy considerations but are available from the corresponding authors on reasonable request.

References

1. Limb, C. J. & Braun, A. R. Neural substrates of spontaneous musical performance: An fMRI study of jazz improvisation. *PLoS ONE*. **3**, e1679. https://doi.org/10.1371/journal.pone.0001679 (2008).
2. Pinho, A. L., de Manzano, Ö., Fransson, P., Eriksson, H. & Ullén, F. Connecting to create: Expertise in musical improvisation is associated with increased functional connectivity between premotor and prefrontal areas. *J. Neurosci.* **34**, 6156–6163. https://doi.org/10.1523/JNEUROSCI.4769-13.2014 (2014).
3. Tachibana, A., Noah, J. A., Ono, Y., Taguchi, D. & Ueda, S. Prefrontal activation related to spontaneous creativity with rock music improvisation: A functional near-infrared spectroscopy study. *Sci. Rep.* **9**, 16044. https://doi.org/10.1038/s41598-019-52348-6 (2019).
4. Jo, K. & Kang, H. J. Comparative analysis on prefrontal cortex activation during piano improvisation and interpretive piano performance using fNIRS. *Korean J. Converg Sci.* **12**, 239–259. https://doi.org/10.24826/KSCS.12.7.15 (2023).
5. Kang, H. J. et al. AI based comparison of prefrontal cortex activity between piano-majors and non-piano-major musicians during score-based playing and Motif-improvisation. *PLoS One*. **20**, e0337458. https://doi.org/10.1371/journal.pone.0337458 (2025).
6. Kang, H. J. Comparative Analysis of Prefrontal Cortex Brain Activity During Score-Playing versus Improvisation and Analysis of Influencing Factors. D.M.A. dissertation, Seoul National University (2024).
7. Meister, I. G. et al. Playing piano in the mind—an fMRI study on music imagery and performance in pianists. *Cogn. Brain Res.* **19**, 219–228. https://doi.org/10.1016/j.cogbrainres.2003.12.005 (2004).
8. Lotze, M., Scheler, G., Tan, H. R. M., Braun, C. & Birbaumer, N. The musician's brain: Functional imaging of amateurs and professionals during performance and imagery. *NeuroImage* **20**, 1817–1829. https://doi.org/10.1016/j.neuroimage.2003.07.018 (2003).
9. Wriessnegger, S. C., Kurzmann, J. & Neuper, C. Spatio-temporal differences in brain oxygenation between movement execution and imagery: A multichannel near-infrared spectroscopy study. *Int. J. Psychophysiol.* **67**, 54–63. https://doi.org/10.1016/j.ijpsycho.2007.10.004 (2008).
10. Yücel, M. A. et al. Best practices for fNIRS publications. *Neurophotonics* **8**, 012101. https://doi.org/10.1117/1.NPh.8.1.012101 (2021).
11. Kirilina, E. et al. The physiological origin of task-evoked systemic artefacts in functional near infrared spectroscopy. *NeuroImage* **61**, 70–81. https://doi.org/10.1016/j.neuroimage.2012.02.074

(2012).

12. Zhang, X., Noah, J. A. & Hirsch, J. Separation of the global and local components in functional near-infrared spectroscopy signals using principal component spatial filtering. *Neurophotonics* **3**, 015004. https://doi.org/10.1117/1.NPh.3.1.015004 (2016).
13. Wu, S., Li, J., Gao, L., Chen, C. & He, S. Suppressing systemic interference in fNIRS monitoring of the hemodynamic cortical response to motor execution and imagery. *Front. Hum. Neurosci.* **12**, 85. https://doi.org/10.3389/fnhum.2018.00085 (2018).
14. Ginzburg, J. et al. Role of the prefrontal cortex in musical and verbal short-term memory: A functional near-infrared spectroscopy study. *Imaging Neurosci.* **2**, imag–2. https://doi.org/10.1162/imag_a_00168 (2024).
15. OBELAB Inc. NIRSIT-Lite User Manual, version 3.5, section 7.2. (2021). https://obelab.com/upload_file/down/%5BOBELAB%5DNIRSIT_Lite_Manual_v3.5ENG.pdf (accessed 18 October 2026).
16. Holm, S. A simple sequentially rejective multiple test procedure. *Scand. J. Stat.* **6**, 65–70. https://doi.org/10.2307/4615733 (1979).
17. Winkler, A. M., Ridgway, G. R., Webster, M. A., Smith, S. M. & Nichols, T. E. Permutation inference for the general linear model. *NeuroImage* **92**, 381–397. https://doi.org/10.1016/j.neuroimage.2014.01.060 (2014).
18. Benjamini, Y. & Hochberg, Y. Controlling the false discovery rate: A practical and powerful approach to multiple testing. *J. R Stat. Soc. B*. **57**, 289–300. https://doi.org/10.1111/j.2517-6161.1995.tb02031.x (1995).

Figures

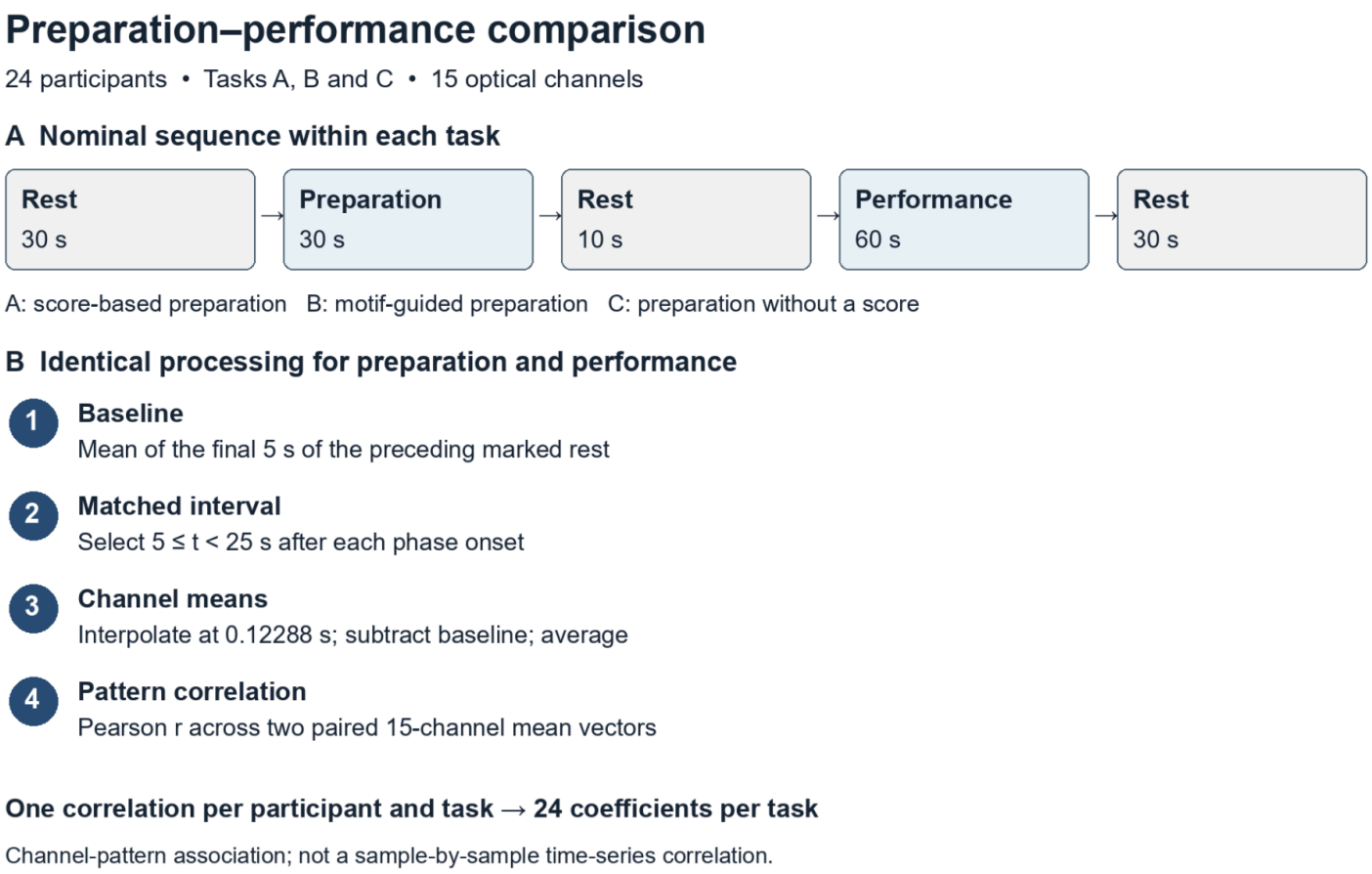


Figure 1

Experimental sequence and analysis workflow. The nominal sequence is shown schematically and not to scale. Preparation in A and B involved a score, whereas preparation in C did not. Each phase was referenced to its own preceding marked-rest baseline and analyzed over the same 5–25 s interval. Pearson correlation across paired channel means gave one coefficient per participant per task. The diagram summarizes the existing analysis and introduces no additional statistical test.

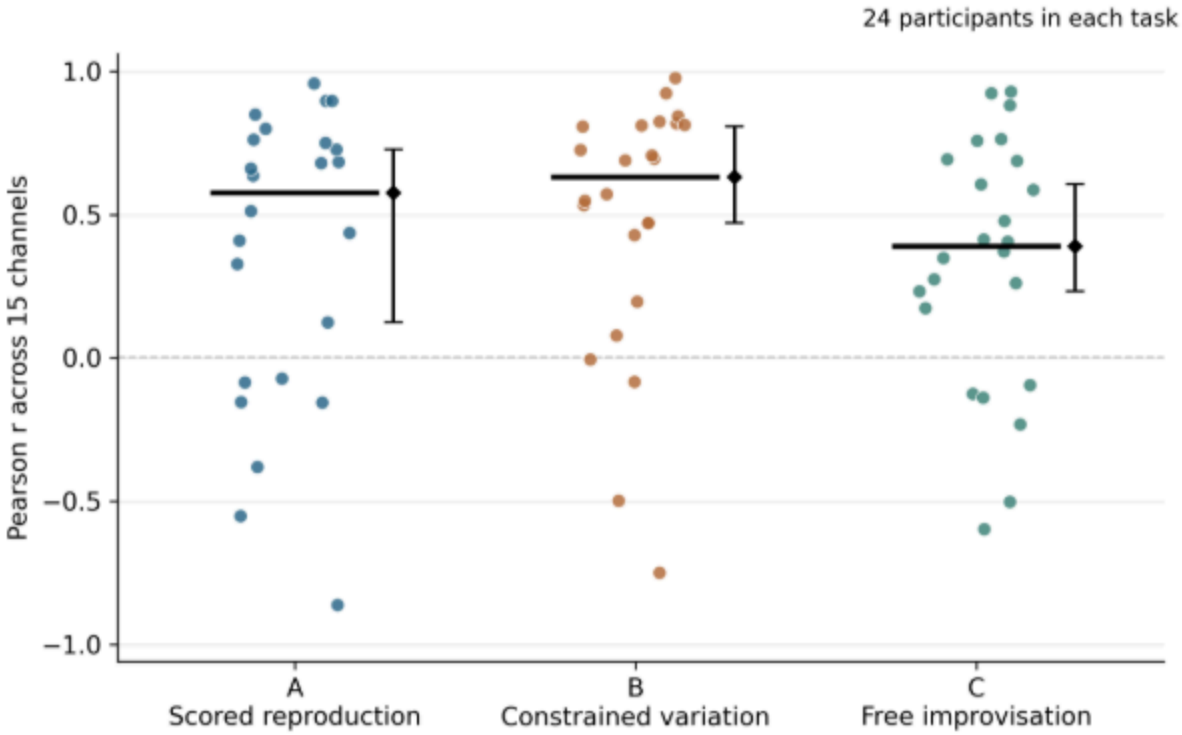


Figure 2

Preparation and performance channel pattern correspondence across musical tasks. Each colored point is one participant's Pearson correlation across the 15 channel means; points are offset horizontally only to reduce overlap. Black horizontal segments mark the medians, and black diamonds with vertical bars show the medians with their participant-bootstrap 95% confidence intervals. The dashed line marks zero correlation. Participant coefficients are plotted to three decimal places, while the median and interval summaries keep the values of the original statistical output. All values are spatial correlations of baseline-subtracted RAW d780 amplitude. Sign-test results and direct task comparisons are reported in the text and Table 2.

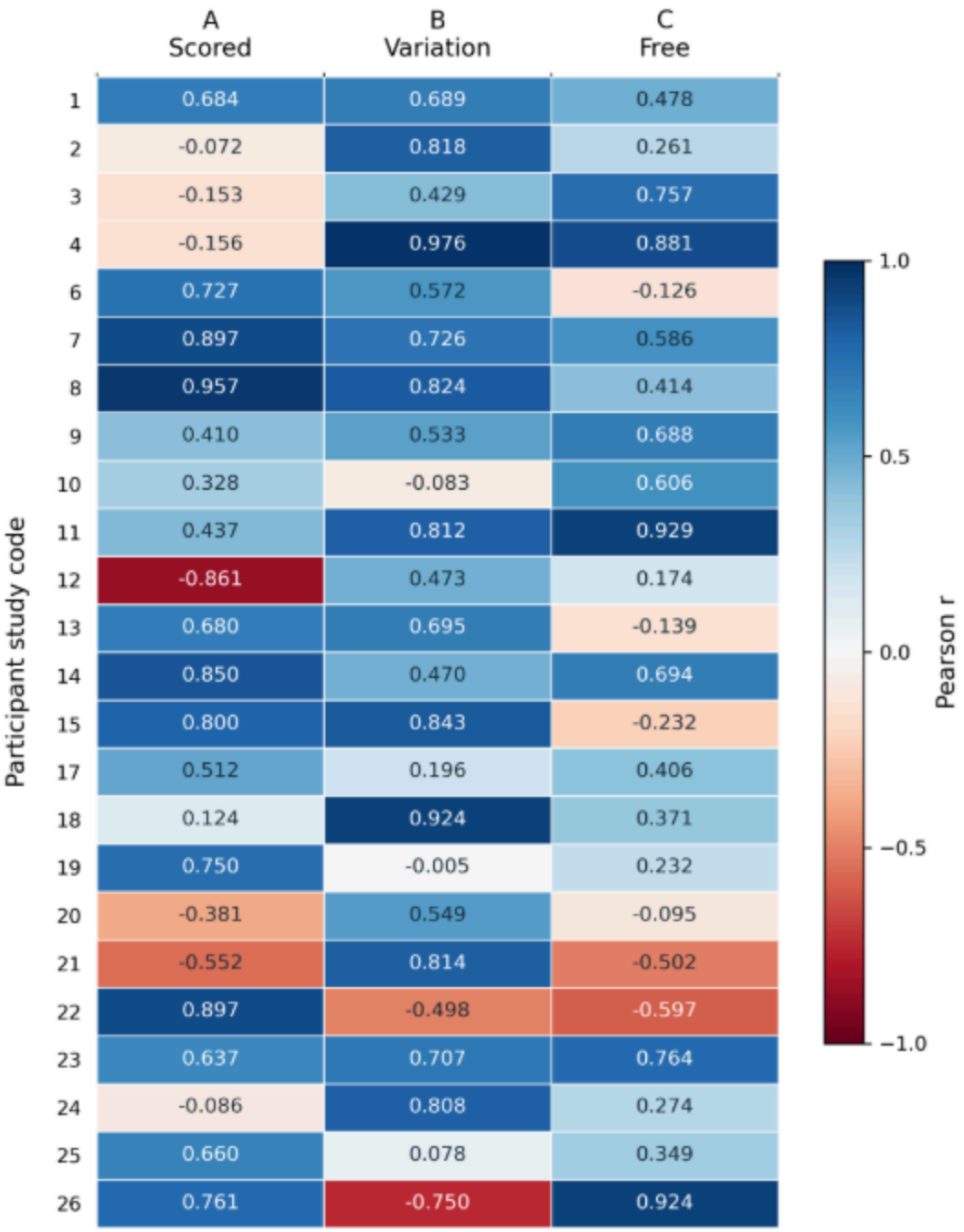


Figure 3

Individual preparation and performance correlations. Rows are participants in ascending study-code order, and columns are tasks A, B and C. Each cell gives the Pearson correlation between the two 15-channel mean-amplitude vectors to three decimal places, on a color scale fixed from −1 to 1. Correlations were positive in all three tasks for 10 participants, in two tasks for 11 and in one task for three. Rows were neither selected nor ordered by correlation magnitude. The coefficients describe individual recordings; they are not tests of individual significance or measures of stable participant traits.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

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