Do musicians have better short-term memory than nonmusicians? A multi-lab study

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on behalf of
The Music Ensemble

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Outline

- “Context” and idea behind this multilab
- “Why/When” it is a good moment to realize a multilab
- “How to” realize a multilab: challenges, problems, and issues in the making of a multilab
- “When the music’s over”: challenges, problems, and issues when the multilab is over

Context

A short theoretical introduction to the topic

Context:
hype on the positive effect of training

The New York Times

How Exercise Strengthens Your Brain

Physical activity improves cognitive and mental health in all sorts of ways. Here's why, and how to reap the benefits.

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SELF-IMPROVEMENT

10 Best Brain Games to Keep Your Mind Sharp

Playing mind games is a no-brainer

By Mark Stibich, PhD | Updated on February 20, 2024

Reviewed by Amy Morin, LCSW

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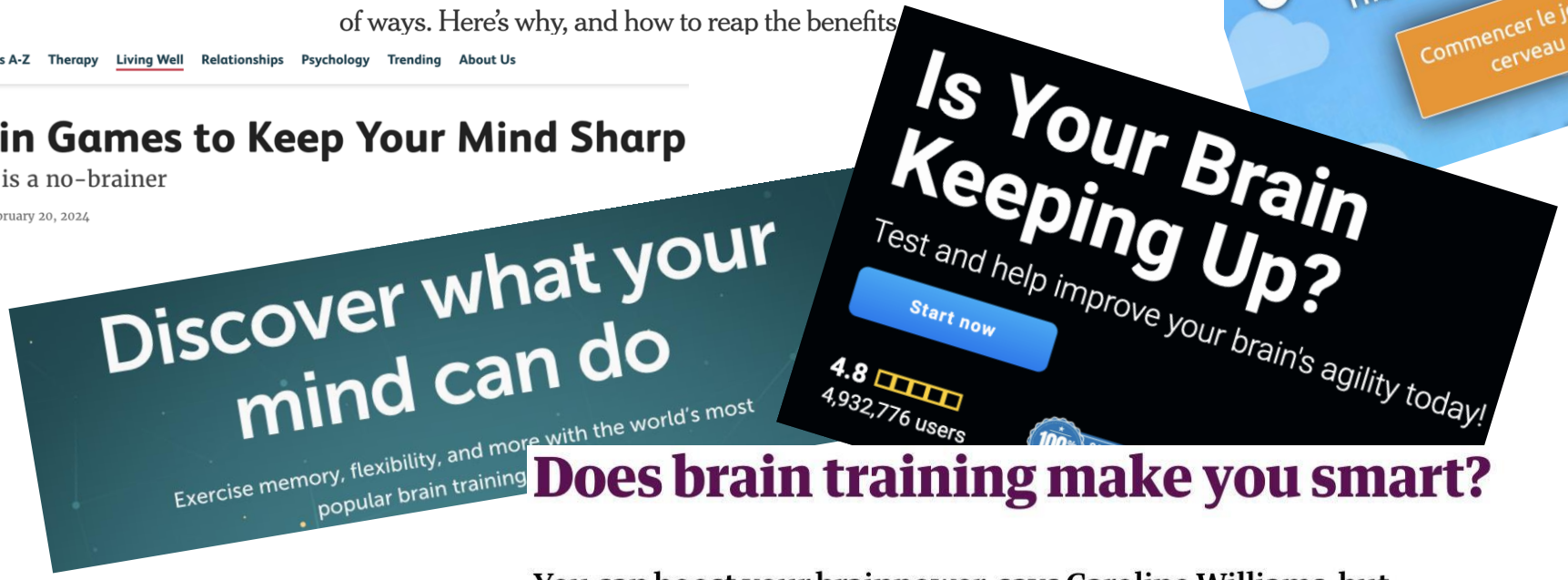

Does brain training make you smart?

You can boost your brainpower, says Caroline Williams, but it's not as simple as just giving your head a work-out

Context:
hype on the positive effects of music training

Context:
is music training beneficial for cognition?

- Several studies (mostly correlational, i.e., musicians vs nonmusicians) investigated the matter
- Music training was found positively associated to:
  - Auditory skills
    - Language skills
      - Higher-level cognitive functions
- Several studies suggest that musicians have better memory than nonmusicians

Why/when “multilab” is the moment to realize a multilab

Of course there is not the “correct answer”

Why/when “multilab”: this multilab emerges from a meta-analysis

- This meta-analysis suggests an advantage in short-term and working memory (medium size), and a small advantage in long-term memory
- The advantage is
  - Large for musical stimuli
    - Medium for verbal stimuli
      - Small-to-null for visuo-spatial stimuli

RESEARCH ARTICLE

Musicians have better memory than nonmusicians: A meta-analysis

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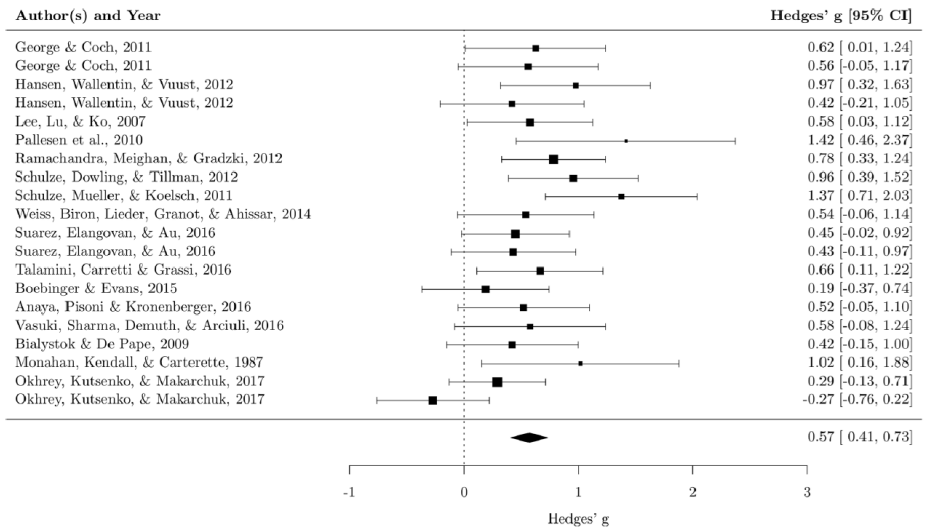


Fig 3. Forest plot for short-term memory. Each square represents the effect size of the study together with the 95% confidence interval. The size of the symbol is proportional to the study's weight.

Why/when “multilab”: can we trust a meta-analysis?

- Yes!
  - It is definitely a numerical way to summarize the literature

- No!
  - Many degrees of freedom in the hands of the analyst
  - Studies included in the meta-analysis have very different protocols
  - If studies are false positive, the outcome of the meta-analysis is unveridical

Why/when “multilab”: “rare” populations & small N

- In our case, the meta analysis included studies that were too small to capture the effect emerging from the mata analysis
- Studies in the literature were small because expert musicians are “rare”
- Usually, literature studies that compare expert musicians with nonmusicians usually recruit ~20 musicians and ~20 nonmusicians
- There are several rare population:
  - patients vs non patients; elite athletes vs non athletes; chess players vs non chess players; etc.

Why/when “multilab”: in practice…

- You need a good reason to begin a multilab: meta analysis (or many meta analyses) may be a good starting point
- You can also challenge a highly debated question in your field…
- or explore possible differences related to culture (e.g. WEIRD vs. non WEIRD participants)...
- or target a rare population (and try to have a decent N)
- …

How to organize a multilab

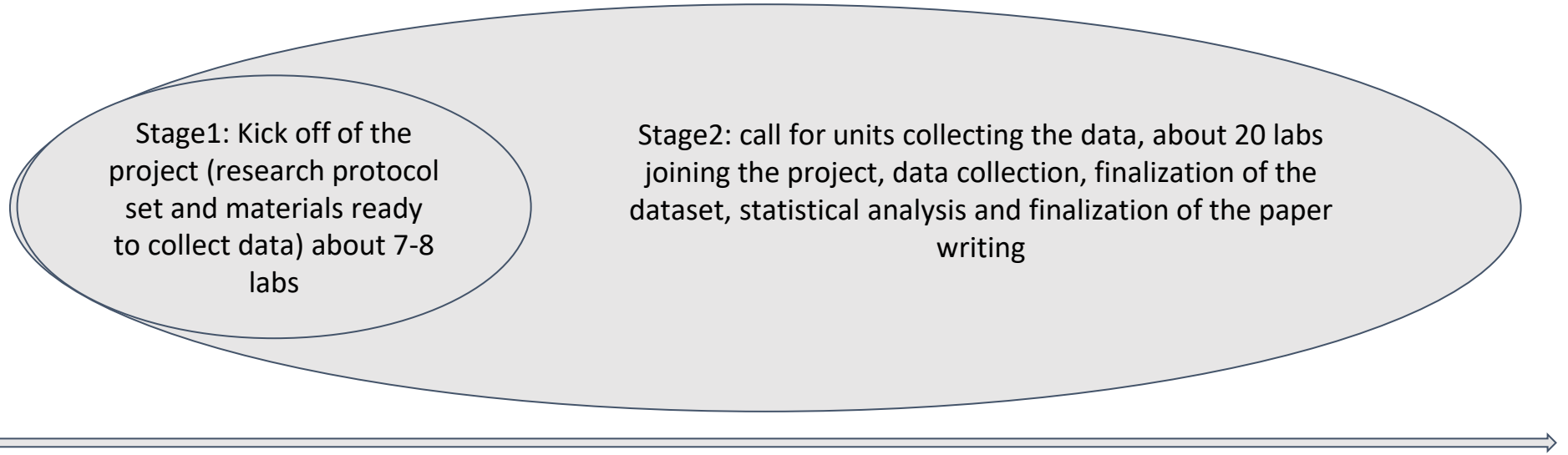
How to keep the mess tidy

How to “multilab”: the very beginning, two options

- Democratic:
  - you call all the experts in the field and start the project
    - Pro: the project (and its results) will be “adopted” by the field
    - Cons: it is difficult to keep people together because they may have contrasting views
- Oligarchic:
  - you decide everything with a limited number of colleagues
    - Pro: the process is faster
    - Cons: results may not be “adopted” by the community

How to “multilab”: our case

- We started from a “small” group of eighteen authors, all involved in the topic (about seven/eight labs)
- After stage1 acceptance (the multilab is a registered report) we disseminated the “call for data collection units”and about twenty units joined the project



How to “multilab”: type of manuscript

- Multilab require a lot of effort from many people
- It is convenient to submit a multilab as a “registered report” (and not a classic article). In this way, if you conduct the study you are guaranteed at least one publication at the end of the process
  - Plus, after stage1 acceptance, when you search for units helping with the data collection they are happy to join the project because the reward is guaranteed
- Keep in mind that, in many cases, one multilab = many publications because the (large) dataset you collect it’s a treasure hiding hidden gems!

How to “multilab”:
if you opt for a registered report…

- Keep contact with the journal, editors and reviewers
- Keep update the journal in case you need to change your protocol

- For example, during our multilab we had to fix some errors in the experimental protocol and change some inclusion/exclusion criteria to adapt them for all the countries involved in the study

How to “multilab”: which colleagues?

- When you search for units that help you collecting the data, keep in mind the type of equipment and expertise they must have
- In our case (we were targeting musicians) we preferred to search for units that were used to recruit musicians because they kwen where to find them

How to “multilab”: how to contact research units

- It is convenient to have a starting core of colleagues with good international networks
- Some journals may help you in looking for research units that will help collecting your data
- In our case, unit-recruitment followed somehow a “snowball recruitment”: we started with a group of colleagues, that contacted other colleagues, that contacted other colleagues…

How to “multilab”: authors and authorship

- Use simple google form to create a database of authors, affiliations, email addresses, type of contribution
- It is convenient to ask the authors the type of contribution in advance [it may be very difficult to decide type of contribution when the data collection is over]
- In some case, the contribution of the colleagues will be less/more than s/he deserves. There is no way to fix this
- [Tools for managing many authors and contributions]

How to “multilab”: keep it simple

- Keep the research design simple: the simpler, the better
- Plan a study that has clear questions and that attempts a simple answer
- If your outcome has 10 possible moderators, you will likely explain only a little portion of it, regardless your tons of data

How to “multilab”: keep it simple (but collect many measures)

- Use well the time of your participants and try to collect as much data as possible
  - Because you collect many observations, even the most remote question of your study (“What’s the color of you bicycle?”) will become a solid result at the end of data collection [e.g.: “Look! 60% of musicians own a red bicycle!”]

How to “multilab”: how to implement it

- Search/use tools that can be implemented online/that are shared and used in the field:
  - Nowadays, tools such as jsPsych enable to conduct experiments (event vision and auditory psychophysics) via web browser
  - If you opt for very diffused tools (e.g. R for stats, all the google suite tools) the majority of collaborators will be ready to help you immediately (no learning required)
- Put everything into a nice and comfortable webpage that may be handy for conducting the experiment

How to “multilab”: how to implement it

- Keep the degrees of freedom to the minimum on the experimenter side
- For example, do not let the experimenter to type-in the name of the unit, the country and other details
  - Everybody does typos and you end up spending hours fixing the data
- Use as much as possible a fixed environment (e.g., dropdown menus, forced choice buttons and so on)

How to “multilab”: verba volant, scripta manent

- Write an “experimenter manual”
- The manual will help the units to collect the data and will reduce the number of emails you’ll receive about the method and the protocol

How to “multilab”: “you say tomato, I say tomato”

- If you plan to work with different countries, keep in mind that even simple things may change from country to country.
- For example:
  - Education:
    - Primary school may start at 4, 5, or 6-yo depending on the country
    - In some country it is easy to take more than one bachelor degree at the same time (e.g., Austria)
    - etc.
  - Test and questionnaires:
    - some tools (e.g., WAIS intelligence test) may have different versions in different countries (e.g., latest edition available: Italy, WAIS-IV; Portugal, WAIS-III)

How to “multilab”: ethics

- Ethics works differently in different countries
  - For some units your “ethic approval” may be sufficient, for others it may be not
- Ethics is definitely one of the first things you need to sort out:
  - no ethics no data!
  - As soon you know which units participate into the data collection, ask them the ethics

How to “multilab”: problems with rare populations

- Often there is not consensus about criteria that identify the “rare population” or criteria may change from country to country
- For example, there is not a standard definition of «musician» (and of «non musician») and the career one may follow to become musicians can be different from country to country

How to “multilab”: communication

- Expect to send/receive many emails!
  - During our project we sent/received about 700 emails (thus far)
- A good organization of the communication is mandatory (i.e. email archiving)
  - [We tried discord too but it did not work for us]
- There are several options for communication (email, telegram, slack/discord, zoom…):
  - “The best” depends on your specific colleagues (e.g., old colleagues may be not so familiar with slack/discord)
- Keep balance: do communicate and provide feedbacks and advancements of the project, but not too much
  - In our case, we were sending 1 or 2 email per month

How to “multilab”: time and timing

- If you give deadlines or set time for zoom meetings, keep in mind that we leave in different time zones
- There are several tool that help you to translate time easily (e.g. even google calendar)
- Holiday are also different from country to country and could affect time and timing (but academics seem to ignore fixed-holidays)

How to “multilab”: how many are “enough”

- The number of units depends on the research question and several other factors
- Although, I guess, it is always convenient to contact more units than the necessary because some may drop the study along the way

How to “multilab”: how many are “enough”

- Two units only: perfect overlap between results of unit1 and 2

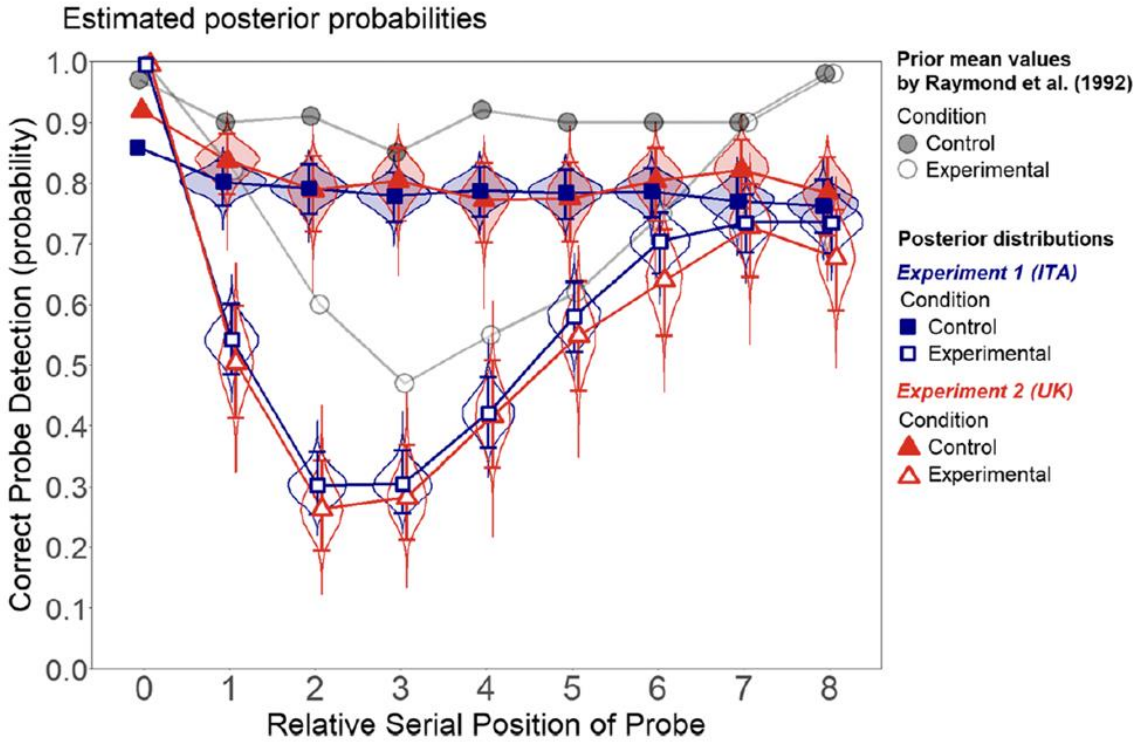
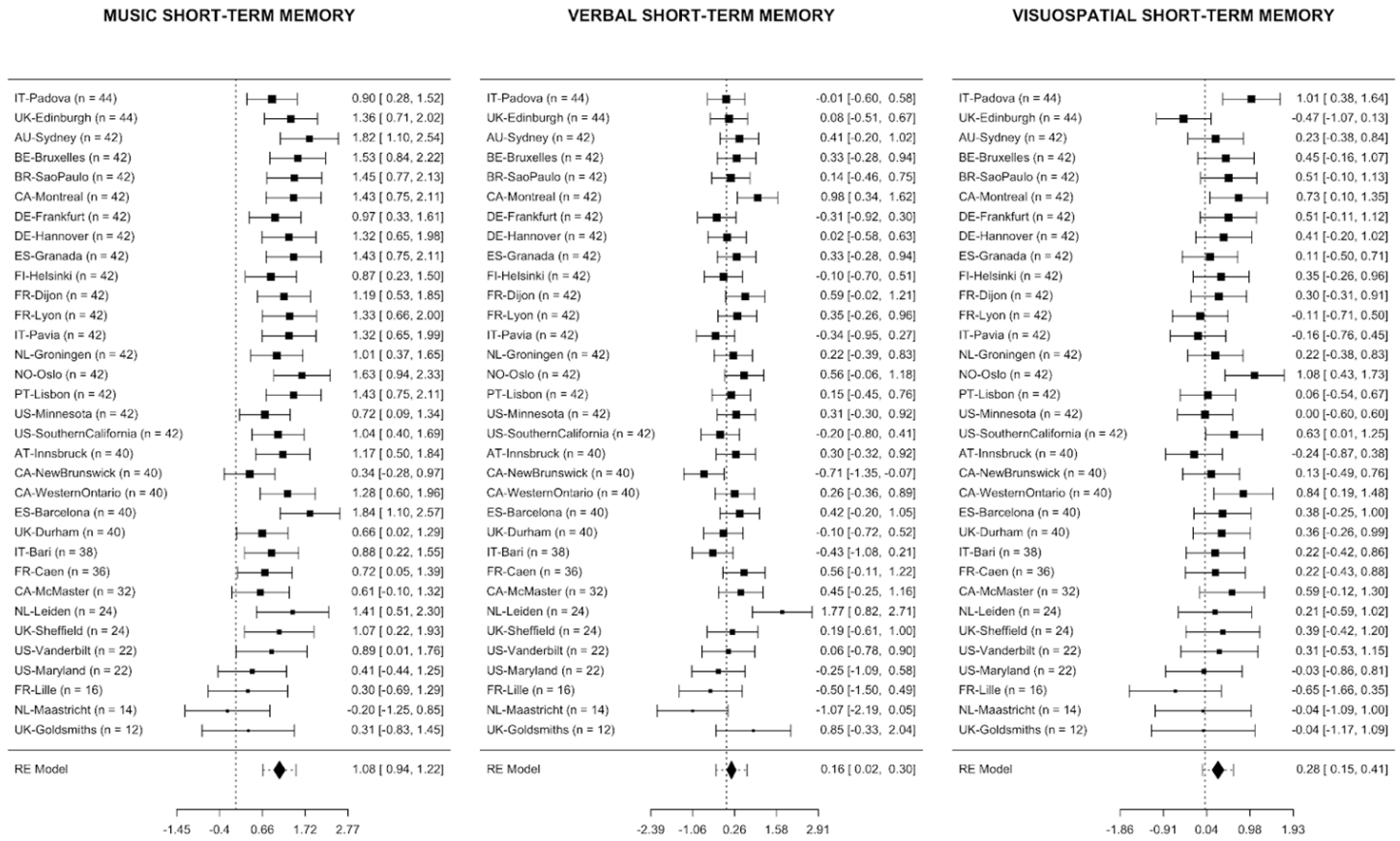


Fig. 1 Estimated accuracy of correct probe detection (conditional on target identification) as a function of Condition and Lag in Experiments 1 and 2. Lag is here referred to as “relative serial position of probe” like in the original experiment by Raymond et al. (1992). The error bars represent the 95% Bayesian credible intervals. The violins represent the entire posterior distributions. The circles represent the estimated prior mean values (thus reproducing the graph in the top panel of Fig. 3 in Raymond et al., 1992). Lag 0 was not included in the model, and its mean accuracies are shown for descriptive purposes only

How to “multilab”: how many are “enough”

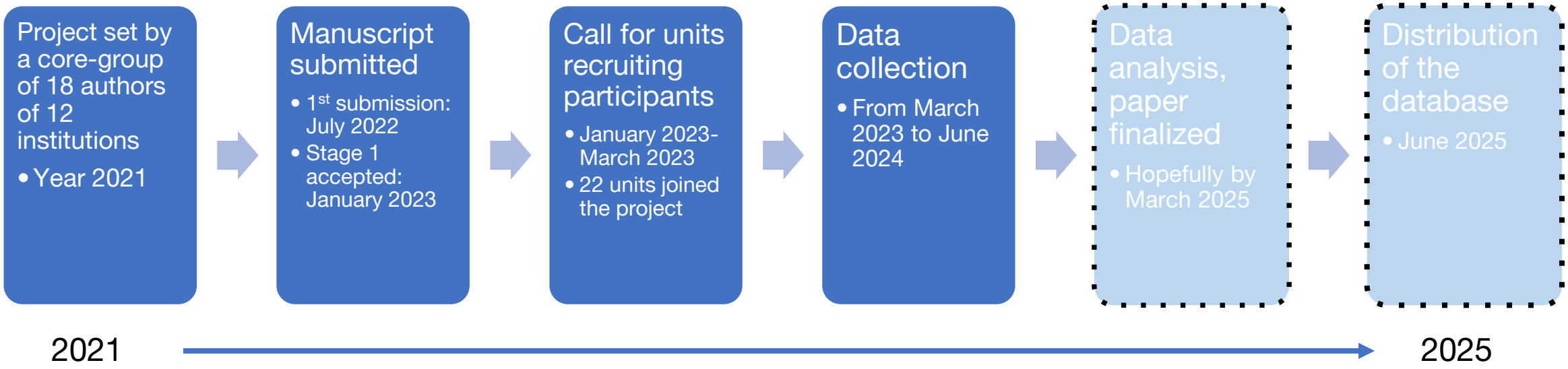
- Many units: contrasting results across units



How to “multilab”: expertise needed

- Set your team so that you have two/three/four colleagues for each expertise you need
- For example, if you have one R-person only, you have a bottleneck in the workflow: when this person is unavailable, your project stops
- Minimum team:
  - manager
  - communication (as nice as chatGPT)
  - analysis scripting (R)
  - experiment scripting (jsPsych)
  - theorist (for contrasting views)
  - data analyst
  - experimenters

How to “multilab”:
be patient, it is a marathon not the 100m



How to “multilab”: duration of the data collection

- The number of continents determines the duration of the data collection.
  - If you have units in the austral hemisphere (Brazil, Australia) they are likely to work when you are having holiday (and vice versa)
- If data collection lasts 1 full year, everybody should be happy

How to “multilab”: provide feedback during the process

- Provide feedback about progress in the project (e.g. “guys! We received the last ethics, we can begin with the data collection!”), about conferences in which you present the project, etc.
- Keep people updated: if you are in the core of the project you will receive a lot of feedback from it. But if you are just collecting data you may feel like a remote island of the Fiji archipelago

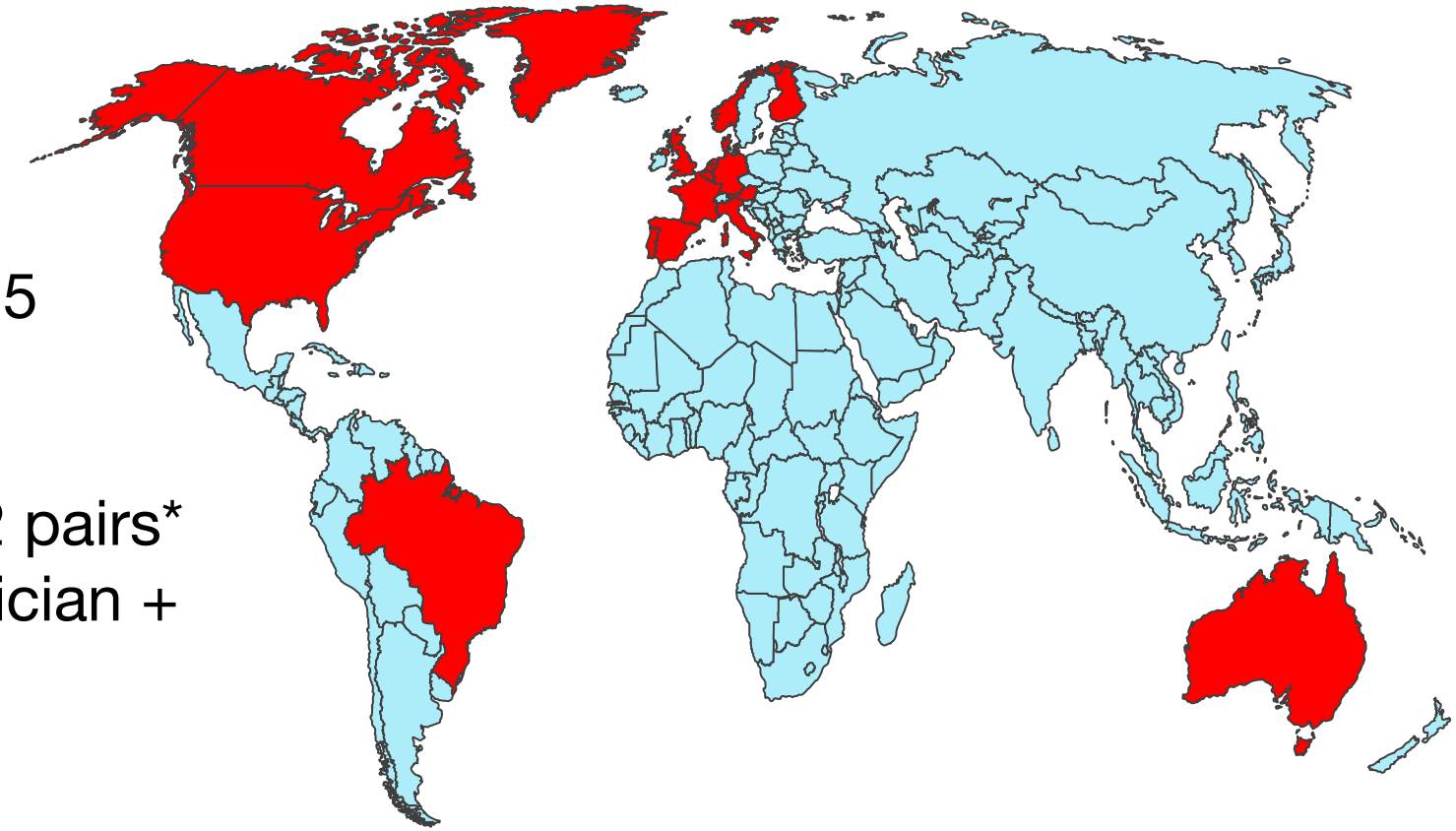
How to “multilab”: provide feedback during the process

- Definitely, provide feedback during data collection so that units know how things are going, they know how they are doing and they know how the rest is doing
- In our case feedback on the progress of data collection was given weekly with a report (a simple google spreadsheet updated weekly)
- This report was very important: tasks were many and experimenters needed to keep into account several characteristics of the participant (age, sex, education). Thanks to the weekly report they had feedback on their own data collection
    - Our weekly report reported details about each subject collected in the study: the subject_ID, age, sex, group (musician/nonmusician), the unit, the country, the task, etc.

“How to” multilab: our members

110 authors from 33 units from 15 different countries

Each unit recruited from 10 to 22 pairs* of participants (one pair = 1 musician + 1 nonmusician)



How to “multilab”: our participants

- 600 musicians*#
- 600 nonmusicians*

- Units recruited from 6+6 to 22+22 participants

*the actual number of participants recruited by the study is larger (over 700 + 700). But some were excluded because they did not complete all the task (usually for technical failure or experimenter’s mistake)
not impressed by this number? The sample includes over 100 absolute pitch possessors. Absolute pitch possessors are 0.01% of the Western population

How to “multilab”: our method

- Laboratory experiment
- Participants took the following short-term memory tasks:
  - Melody span (short-term memory for music)
  - Digit span (short-term memory for verbal stimuli presented visually)
  - Spatial span (short-term memory for spatial stimuli: a dot moving on a 4x4 matrix)

How to “multilab”: our method

- Control variables
  - 2-back task: control for differences in executive functions (WM)
  - Raven matrices: control for differences in fluid intelligence
  - WAIS-vocabulary: control for differences in crystallized intelligence
  - BFI-2: control for differences in personality
  - PROMS: assessment of music perception skills
  - GOLD-MSI: assessment of music sophistication
  - eBMRQ: assessment of reward from music
  - Hollingshead: assessment of socio-economic status
  - Additional custom questions on expertise of participants

When the music’s over”

challenges, problems, and issues when the multilab is over

When the music's over: fixing fixing fixing

- No matter how good is your setup and your collaborators, when the data collection is over you will spend a lot of data fixing the data
  - For example, in our case, the participant was taking several tasks, and the experimenter (by mistake) could transform the same participant into "male", "female" or "non binary" across the various tasks
- At the end of data collection we had to zoom with units one by one to fix the demographics of each participant
- It is fundamental that units and experimenter keep a good lab-book-record of the participants they recruit

When the music’s over:
is the glass half empty or half full

- Multilabs return authoritative results: do not exaggerate with statements/interpretations about the results
  - results and data will last longer than your interpretation

When the music's over:
is the glass half empty or half full

- If your multilab returns a result that is something like a "glass half empty, half full", be ready for a battle among authors to push for one (or the other) interpretation
- It may be convenient to try to predict possible outcomes and discuss with authors *before data are collected* how various, unexpected outcomes will be interpreted
- Consider also the option to write explicitly in the discussion that authors do not agree on a specific interpretation, and report all the alternative views (in the very end, we are humans: if we are many, we cannot agree on everything)

When the music’s over:
set up you materials for the future

- Data collection may continue after the first publication
- Materials and data may be reused: keep your stuff tidy and clean during the whole process

When the music’s over:
keep track of “what’s next?”

- When data will be available, authors will begin their own analysis
- It may be convenient to ask colleagues participating in the multilab about “what do you plan to do next with this data?”
- Keep track of the ideas about successive analysis and/or integrative/successive data collections so that different units avoid to conduct the same study

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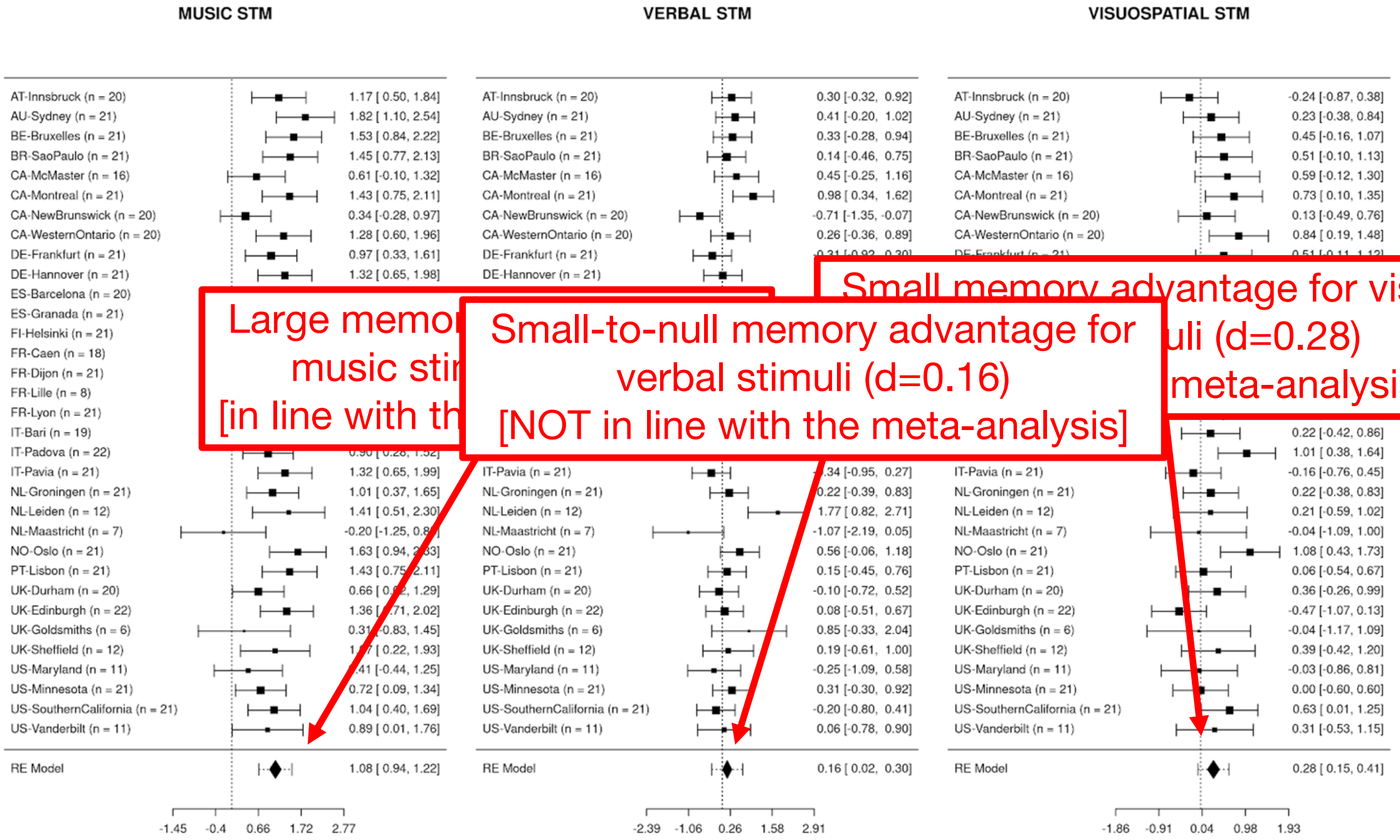
…and if you are interested in the results

see next two slides


MUSIC STM
AT-Innsbruck (n = 20) 1.17 [0.50, 1.84]
AU-Sydney (n = 21) 1.82 [1.10, 2.54]
BE-Bruxelles (n = 21) 1.53 [0.84, 2.22]
BR-SaoPaulo (n = 21) 1.45 [0.77, 2.13]
CA-McMaster (n = 16) 0.61 [-0.10, 1.32]
CA-Montreal (n = 21) 1.43 [0.75, 2.11]
CA-NewBrunswick (n = 20) 0.34 [-0.28, 0.97]
CA-WesternOntario (n = 20) 1.28 [0.60, 1.96]
DE-Frankfurt (n = 21) 0.97 [0.33, 1.61]
DE-Hannover (n = 21) 1.32 [0.65, 1.98]
ES-Barcelona (n = 20)
ES-Granada (n = 21)
FI-Helsinki (n = 21)
FR-Caen (n = 18)
FR-Dijon (n = 21)
FR-Lille (n = 8)
FR-Lyon (n = 21)
IT-Bari (n = 19)
IT-Padova (n = 22)
IT-Pavia (n = 21) 1.32 [0.65, 1.99]
NL-Groningen (n = 21) 1.01 [0.37, 1.65]
NL-Leiden (n = 12) 1.41 [0.51, 2.30]
NL-Maastricht (n = 7) -0.20 [-1.25, 0.8
NO-Oslo (n = 21) 1.63 [0.94, 2.3
PT-Lisbon (n = 21) 1.43 [0.75, 2.11]
UK-Durham (n = 20) 0.66 [0.
UK-Edinburgh (n = 22) 1.36 [.71, 2.02]
UK-Goldsmiths (n = 6) 0.31 -0.83, 1.45]
UK-Sheffield (n = 12) 1. 0.22, 1.93]
US-Maryland (n = 11) .41 [-0.44, 1.25]
US-Minnesota (n = 21) 0.72 [0.09, 1.34]
US-SouthernCalifornia (n = 21) 1.04 [0.40, 1.69]
US-Vanderbilt (n = 11) 0.89 [0.01, 1.76]
RE Model 1.08 [0.94, 1.22]
-1.45 -0.4 0.66 1.72 2.77
VERBAL STM
AT-Innsbruck (n = 20) 0.30 [-0.32, 0.92]
AU-Sydney (n = 21) 0.41 [-0.20, 1.02]
BE-Bruxelles (n = 21) 0.33 [-0.28, 0.94]
BR-SaoPaulo (n = 21) 0.14 [-0.46, 0.75]
CA-McMaster (n = 16) 0.45 [-0.25, 1.16]
CA-Montreal (n = 21) 0.98 [0.34, 1.62]
CA-NewBrunswick (n = 20) -0.71 [-1.35, -0.07]
CA-WesternOntario (n = 20) 0.26 [-0.36, 0.89]
DE-Frankfurt (n = 21)
DE-Hannover (n = 21)
IT-Pavia (n = 21) .34 [-0.95, 0.27]
NL-Groningen (n = 21) .22 [-0.39, 0.83]
NL-Leiden (n = 12) 1.77 [0.82, 2.71]
NL-Maastricht (n = 7) -1.07 [-2.19, 0.05]
NO-Oslo (n = 21) 0.56 [-0.06, 1.18]
PT-Lisbon (n = 21) 0.15 [-0.45, 0.76]
UK-Durham (n = 20) -0.10 [-0.72, 0.52]
UK-Edinburgh (n = 22) 0.08 [-0.51, 0.67]
UK-Goldsmiths (n = 6) 0.85 [-0.33, 2.04]
UK-Sheffield (n = 12) 0.19 [-0.61, 1.00]
US-Maryland (n = 11) -0.25 [-1.09, 0.58]
US-Minnesota (n = 21) 0.31 [-0.30, 0.92]
US-SouthernCalifornia (n = 21) -0.20 [-0.80, 0.41]
US-Vanderbilt (n = 11) 0.06 [-0.78, 0.90]
RE Model 0.16 [0.02, 0.30]
-2.39 -1.06 0.26 1.58 2.91
VISUOSPATIAL STM
AT-Innsbruck (n = 20) -0.24 [-0.87, 0.38]
AU-Sydney (n = 21) 0.23 [-0.38, 0.84]
BE-Bruxelles (n = 21) 0.45 [-0.16, 1.07]
BR-SaoPaulo (n = 21) 0.51 [-0.10, 1.13]
CA-McMaster (n = 16) 0.59 [-0.12, 1.30]
CA-Montreal (n = 21) 0.73 [0.10, 1.35]
CA-NewBrunswick (n = 20) 0.13 [-0.49, 0.76]
CA-WesternOntario (n = 20) 0.84 [0.19, 1.48]
0.22 [-0.42, 0.86]
1.01 [0.38, 1.64]
IT-Pavia (n = 21) -0.16 [-0.76, 0.45]
NL-Groningen (n = 21) 0.22 [-0.38, 0.83]
NL-Leiden (n = 12) 0.21 [-0.59, 1.02]
NL-Maastricht (n = 7) -0.04 [-1.09, 1.00]
NO-Oslo (n = 21) 1.08 [0.43, 1.73]
PT-Lisbon (n = 21) 0.06 [-0.54, 0.67]
UK-Durham (n = 20) 0.36 [-0.26, 0.99]
UK-Edinburgh (n = 22) -0.47 [-1.07, 0.13]
UK-Goldsmiths (n = 6) -0.04 [-1.17, 1.09]
UK-Sheffield (n = 12) 0.39 [-0.42, 1.20]
US-Maryland (n = 11) -0.03 [-0.86, 0.81]
US-Minnesota (n = 21) 0.00 [-0.60, 0.60]
US-SouthernCalifornia (n = 21) 0.63 [0.01, 1.25]
US-Vanderbilt (n = 11) 0.31 [-0.53, 1.15]
RE Model 0.28 [0.15, 0.41]
-1.86 -0.91 0.04 0.98 1.93
Large memo
music stir
[in line with th
Small-to-null memory advantage for verbal stimuli (d=0.16)
[NOT in line with the meta-analysis]
Small memory advantage for visuo-
uli (d=0.28)
meta-analysis]

Additional results

Performance

- Musicians perform better in the
  - N-back [executive functions]: d=0.33
  - Raven test [fluid intelligence]: d=0.26
  - WAIS vocabulary [crystallized intelligence]: d=0.4
  - PROMS [music perception skills]: d=1.69

Status

- Musicians are more
  - GOLD-MSI [musically sophisticated]: d=3.28
  - eBMRQ [rewarded from music]: d=1.07
  - Hollingshead [rich]: d=0.36
  - BFI2:
    - Agreableness: d=0.32
    - Conscientiousness: d=0.17
    - Extrovert: d=0.32
    - Negative emotionality: d=-0.06
    - Open-minded: d=0.87