Nonmusicians with High Music Perception: A Distinct Category in Visuospatial & Surgical Skill Assessment

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INTRODUCTION

According to the theory of multiple intelligences, spatial intelligence (SI) is the ability to recognize and manipulate spatial images (1). The Cattell-Horn-Carroll (CHC) theory refines this concept, defining spatial ability as "visual processing"—the capacity to perceive, analyze, and transform visual patterns and stimuli to solve problems (2). SI is commonly measured by mental rotation (MR) tasks, which are strongly linked to STEM success (3-6) and particularly valued in hands-on medical training, like anatomy and surgery (7-9). SI is also crucial in music, where musicians often excel in visuospatial tasks (10-16) and perform better in surgical tasks than non-musicians, likely due to neuroplasticity and cognitive transfer from musical practice (17-23). However, categorizing individuals solely as musicians or non-musicians overlooks "musical sleepers": non-musicians with high music perception (MP) who may possess the genetic or environmental potential for musicianship but lack motivation, financial means, or guidance (24). This study addresses this gap by measuring MP and classifying musical sleepers as a distinct group among female first-year medical students. It examines differences in MR ability across these three groups and investigates correlations between MP and surgical task performance (SP), controlling for known covariates like MR, age, gender, and handedness (25-44).

MATERIAL & METHODS

Fig.1

Fig.2

Fig.3

Study Design: This cross-sectional study investigated differences in mental rotation (MR) ability among three groups—musicians **(M)**, musical sleepers **(S)**, and non-musicians **(N)**. It also explored correlations between music perception (MP) and MR ability, and the impact of MP on surgical skills, controlling for MR.

Participants: After ethical approval (IEC No. SIU/IEC/642), 150 consenting, right-handed, female, first-year medical students (mean age = 20.19 ± 1.29) participated. Exclusion criteria included those with known hearing, visuospatial, or fine-motor impairments; proficiency in sign language; advanced gaming or state-level athletics experience; left-handedness; ambidexterity; dance training; or skills in crochet/embroidery, as well as prior surgical workshop attendance.

Procedure:

- **Music Perception Test (Fig. 1):** Participants completed the **miniPROMS**, a validated, condensed test of the PROMS designed to assess musical perception dimensions, including pitch, timbre, rhythm, and loudness (45, 46). Using their own earphones, participants scored on a 0–30 scale in approximately 15 minutes.
- **Mental Rotation Task (MRT) (Fig. 2):** Following the miniPROMS, participants completed the Vandenberg and Kuse MRT, which assesses spatial manipulation and working memory (3, 4). The MRT involved ten trials, each presenting a three-dimensional figure, with participants identifying the rotated equivalent among four options. Scoring was on a ten-point scale.
- **Surgery Knot-Tying Task (Fig 3):** Due to scheduling, only 56 students completed the knot-tying task. After a 30-minute instructional video and a 60-minute practice session, participants attempted a one-handed surgical knot on a cadaveric intestinal tissue, holding the needle-end with the non-dominant hand (two throws). Each performance was video-recorded (1080p, 30 fps) from a bird's-eye view and evaluated by two surgical experts using a validated checklist (47).

Data Collection: Anonymized data were collected via Google Form, where informed consent was obtained. Participants completed the miniPROMS and MRT under invigilation in a lecture hall, uploading screenshots of scores. The surgical task was performed in batches of 12 students over five days, with four stations per day and three students per station. Each session included a 90-minute pre-task briefing (video lecture, practice on a cup handle, and on cadaveric tissue). Tutors supervised and invigilated, ensuring only participants' hands were visible in recordings to maintain anonymity.

RESULTS

We categorized students into musicians (M), musical sleepers (S), and non-musicians (N), with musical sleepers identified based on miniPROMS scores above the sample median of 17 **(Table 1)**. A Shapiro-Wilk test indicated a non-normal distribution **(Fig. 4)** for MR ($p<0.001$), so we used a Kruskal-Wallis test for group comparisons **(Fig. 5).**

Table 1 - Descriptive Statistics for MP and MR by Group

Group	N	Mean_MP	SD_MP	Min_MP	Max_MP	Mean_MR	SD_MR	Min_MR	Max_MR
M	24	21.41667	4.898240	12.0	30	65.83333	16.39636	30	90
S	53	20.48113	2.341027	17.5	26	56.41509	19.81592	10	90
N	73	14.10959	2.284073	7.5	18	47.67123	20.10532	10	90

Fig. 4 - Distribution of MR Scores

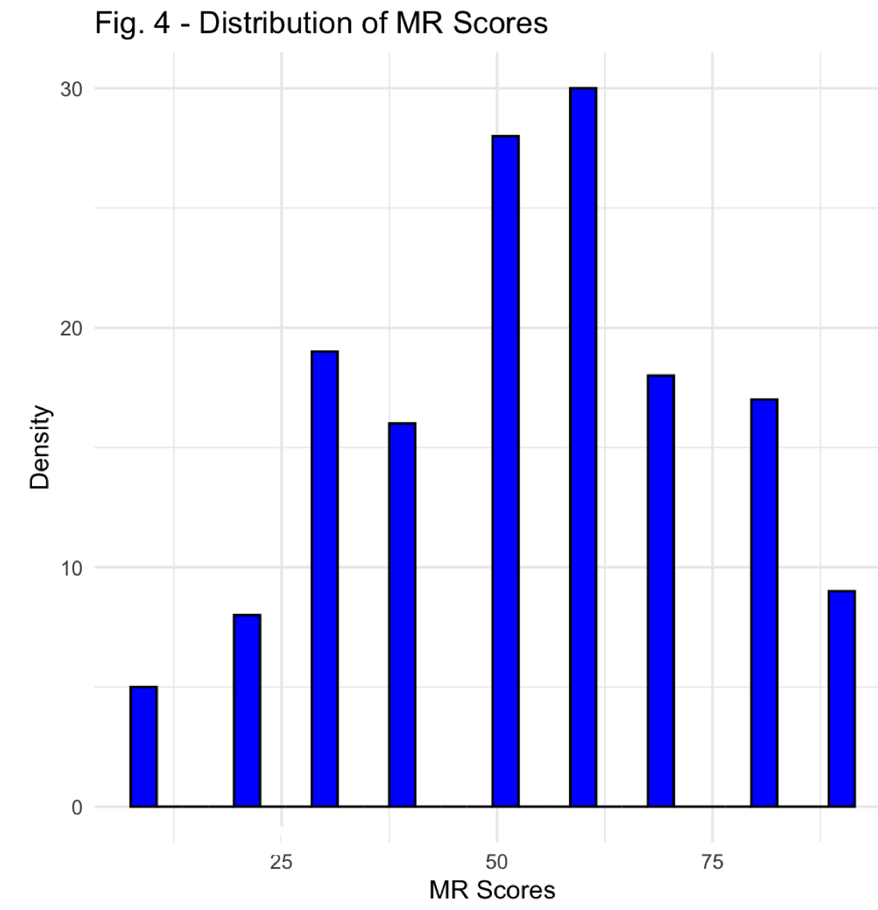
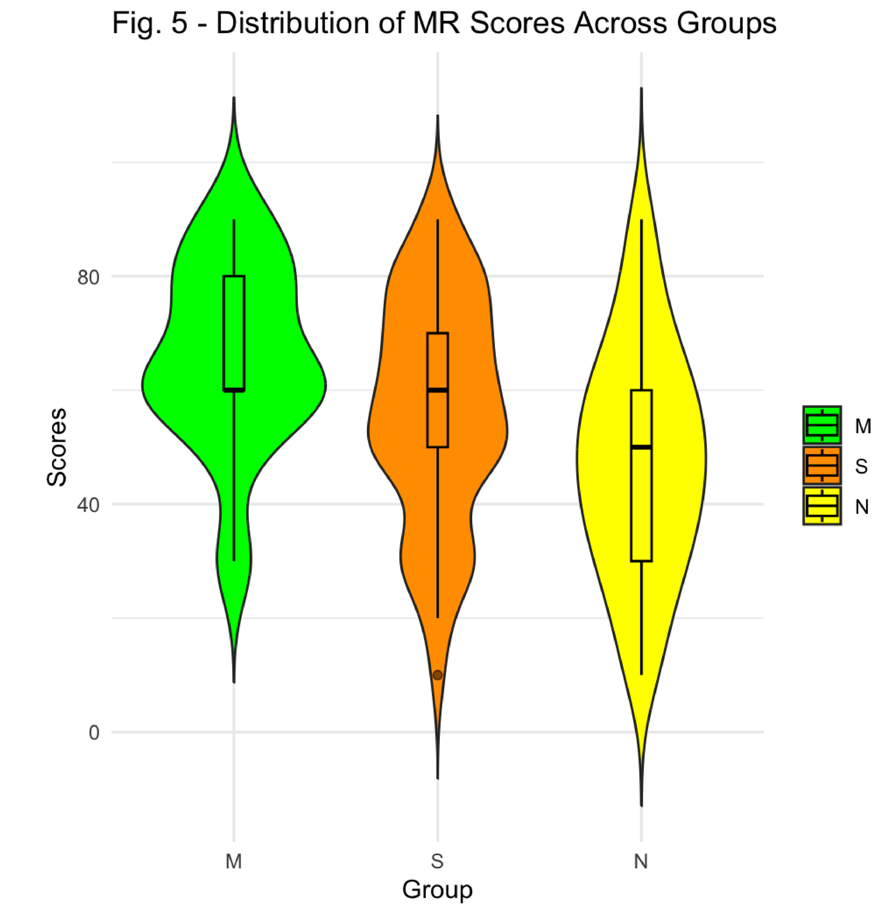


Fig. 5 - Distribution of MR Scores Across Groups



Results showed significant differences in MR ability across groups **[H(2)=18.808, p<0.001, η²=0.114, Cohen's f=0.359]**. Post hoc with Bonferroni correction revealed that musicians outperformed non-musicians with a large effect size **[mean rank difference=41.90, p<0.001, r=0.432]** but did not significantly differ from musical sleepers **[mean rank difference=20.11, p=0.156, r=0.210]**. Musical sleepers outperformed non-musicians with a small-to-medium effect size **[mean rank difference=21.78, p=0.013, r=0.253]**. The Shapiro-Wilk test also showed non-normal distribution for surgical task performance **(SP)** ($p<0.001$). Excluding musicians, we compared SP between S and N groups using the Mann-Whitney U test, finding no significant difference **[N=49, mean rank difference=6.17, p=0.094, r=0.239] (Fig. 6)**. Post-hoc power analysis indicated a power of 0.394. Correlation analysis showed a weak positive correlation between MP and MR **[r=0.241, p=0.003]**. Partial correlation analysis controlling for MR revealed a slightly weaker positive correlation between MP and SP **[r=0.268, p=0.048] (Fig. 7)**.

Fig. 6 - Distribution of SP Across Groups S and N

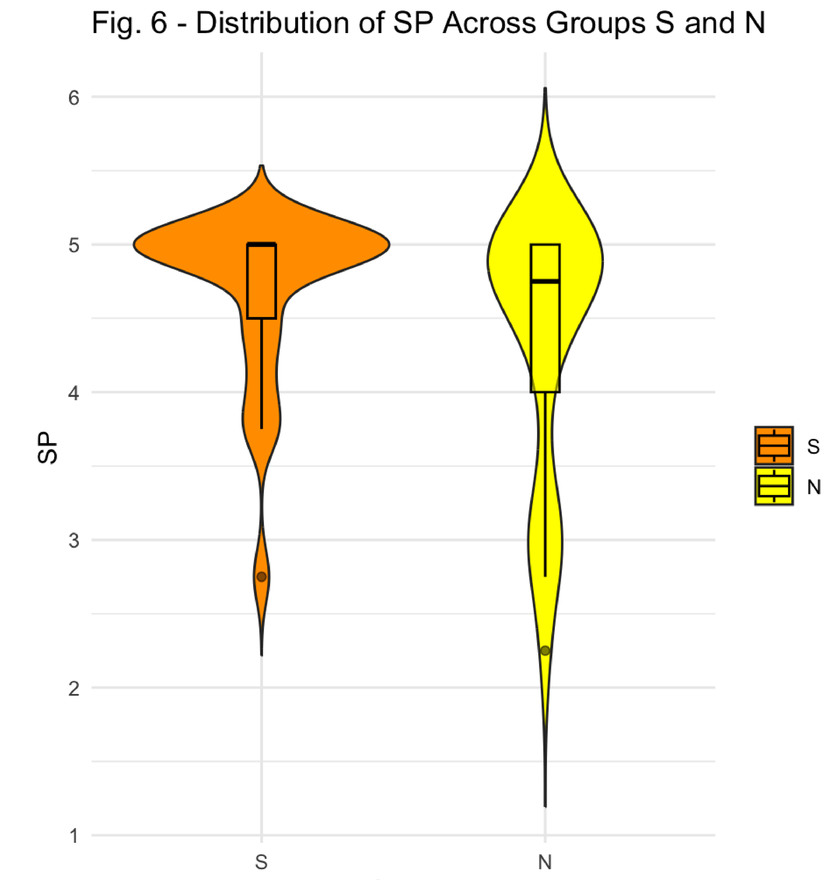
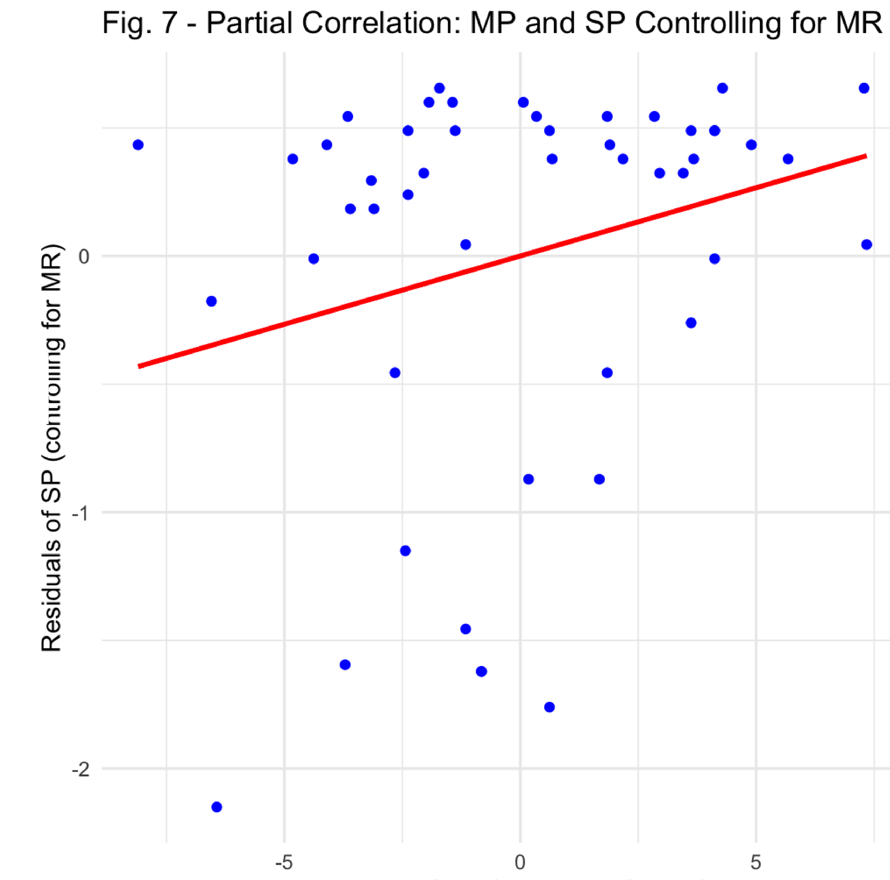


Fig. 7 - Partial Correlation: MP and SP Controlling for MR



CONCLUSION

We conclude that non-musicians with high music perception outperform those with poor music perception in mental rotation tasks, indicating a spatial advantage independent of musical practice. This group warrants recognition as a distinct category in music cognition research. Future studies should explore whether this spatial advantage aids surgical skill acquisition, particularly through longitudinal assessments and interdisciplinary approaches like music training.