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THEORETICAL/REVIEW

Handedness and creativity: Facts and fictions

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Abstract

Are left-handers more creative than right-handers? In both popular belief and scientific literature, left-handedness is linked with higher creativity. In a qualitative review supported by meta-analyses, here we evaluated whether left- or mixed-handers are more creative than right-handers, as measured by tests of divergent thinking, and evaluated whether left- or mixed-handers are overrepresented in creative professions. We argue that plausible mechanisms for a link between creativity and handedness can be found within influential theories of the neural basis of creativity. However, we found no evidence that left- or mixed-handers are more creative than right-handers; on the contrary, right-handers scored statistically higher on one standard test of divergent thinking (the Alternate Uses Test). Additionally, although left- and mixed-handers may be overrepresented in Art and Music, they are underrepresented in creative professions, in general. Both right and left-handers tend to *believe* that left-handers are more creative, but this belief is not supported by the available empirical evidence.

Keywords Creativity · Divergent thinking · Handedness · Meta-analysis · Review

What do Leonardo da Vinci, M. C. Escher, and Jimi Hendrix have in common? Not only were they all creative geniuses, they were also all left-handed. The existence of such stellar sinistrals may help to fuel the widespread belief that left-handedness is linked with artistic excellence. Popular media articles state that "lefties are more creative" than righties as if it were an established fact (Mallya, 2019). Within the scientific literature, researchers have advanced the narrower claim that left-handers are better at one particular cognitive process underlying creativity—*divergent thinking*, the ability to explore many possible solutions to a problem in a short time, which sometimes leads to connections between distantly related concepts and unusual ideas (e.g., Heilman, 2021; Lindell, 2011; Prichard et al., 2013). This claim is supported by a few often-cited studies reporting that left-handers (Coren, 1995; Newland et al., 1981) or mixed-handers (Shobe et al., 2009) show an advantage on laboratory tests of divergent thinking. Although review papers have discussed the relationship between creativity and hemispheric asymmetry (Lindell, 2011) and the relationship between handedness and cognitive abilities in general (e.g., Fritsche & Lindell, 2019; Prichard et al., 2013), to date, no review has provided a targeted evaluation of the evidence for the claim that left- or mixed handedness confers an advantage in creative thinking.

In this article, we will first review two leading theories of the neural basis of creativity and will propose that either of these theories could provide a potential explanation for how handedness might influence creativity. Second, we will evaluate the evidence that left-handedness confers an advantage on laboratory tests that measure divergent thinking and will support our qualitative review with meta-analyses. Third, we will review the evidence that left-handers may be overrepresented in creative fields, such as music and architecture. Finally, we will discuss evidence that left-handers think of themselves as being more creative than right-handers do.

To preview our findings, we do not find any evidence that left-handers are more creative than right- or mixed-handers. On the contrary, *right-handers* may have a slight advantage

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on at least one standard measure of divergent thinking. Beyond the lab, left-handers may be overrepresented in art and music. However, we find no evidence that left-handers are overrepresented in creative professions in general; rather, *right-hander*s are overrepresented in professions that require the greatest creativity. Two well-established theories of creativity motivate the belief that left- or mixed-handers should be especially creative, but this belief is not supported by the available evidence.

Theories of creativity in the brain

Why would handedness matter for creativity? Two theories of creativity potentially motivate the hypothesis that left-handers should be more creative than right-handers (see Table 1). First, the right hemisphere theory proposes that brain areas in the right hemisphere are critically involved in creative thinking (e.g., Aberg et al., 2017; Beeman et al., 1994; Fink & Benedek, 2013). As formulated by Kounios and Beeman (2014), the right hemisphere might support creative problem-solving through its relatively "coarse semantic coding." On this account, the associative cortex in the left hemisphere tends to represent concepts in narrow, closely overlapping "semantic fields," whereas the associative cortex in the right hemisphere tends to represent distantly related concepts in broad, loosely overlapping fields (Jung-Beeman, 2005; see also Coulson, 2001; Faust, 2012; Zeev-Wolf et al., 2014). This coarse semantic coding would facilitate connecting distantly related concepts during insightful problem-solving. Supporting the right hemisphere theory, many neuroimaging studies have found that right hemisphere areas are preferentially active during creative thinking (see Mihov et al., 2010, for a review).

The right hemisphere theory could explain why left-handers would be more creative than right-handers by applying Kinsbourne and Hicks's (1978) concept of "overflow" of neural activity. According to Kinsbourne and Hicks, activity in a given brain region can facilitate activity in others that are "functionally close." Functional distance is determined by the density of direct neural connections between brain regions and correlates with the spatial distance between them (Kinsbourne & Hicks, 1978). Supporting this principle of functional distance, electrophysiological connectivity suggests that primate brains tend to show "small world" network patterns, with adjacent areas tending to have greater functional connectivity (Stephan et al., 2000). Because left-handed people habitually activate motor areas on the right side of the brain when they perform manual actions, nearby right hemisphere areas that support coarse semantic coding might become activated via overflow of motor activity. Accordingly, activity in these right hemisphere areas could become habitually facilitated, resulting in a left-hander advantage in divergent thinking. Supporting the idea that left-hand action could facilitate divergent thinking via hemispheric activation, Goldstein et al. (2010) found that participants who squeezed a ball with their left hand for several minutes showed higher divergent thinking compared with participants who squeezed a ball with their right hand and to participants in a baseline condition who did not squeeze a ball (see also Rominger et al., 2014; but see Turner et al., 2017, which found a reversed laterality effect). Via overflow of motor-related cortical activity, simply using one's dominant hand habitually to perform everyday actions could increase left-handers' creativity relative to right-handers (cf. Heilman, 2021). On this view, mixed-handers, who use their left hand for more activities than right-handers, should be intermediate in creativity.

According to a different theory, creativity depends on the *interhemispheric transfer* of information (e.g., Heilman, 2005; Lindell, 2011). In this proposal, the two hemispheres tend to represent different kinds of information (e.g., linguistic vs. spatial; categorical vs. continuous metrics), and the ability to make connections between distantly related ideas requires interhemispheric communication (Heilman, 2005). Some neuroimaging findings support this theory: for example, Carlsson et al. (2000) found that highly creative people showed more bilateral

Table 1 How theories of creativity in the brain could predict a relation between handedness and creativity

Theory	Predictions	Potential mechanism
Right hemisphere theory	Left-handers should have greater creativity than mixed- and right-handers Mixed-handers should show greater creativity than right-handers	Left-handers' frequent dominant-hand actions may activate right hemisphere coarse semantic coding areas via neural "overflow"; more right-handers'; mixed-handers may have an intermediate amount of overflow
Interhemispheric transfer theory	Left- and mixed-handers should show greater creativity than right-handers	Higher interhemispheric connectivity in left- or mixed-handers could facilitate the integration of distantly related concepts

blood flow in frontal brain areas during a divergent-thinking task compared with less creative people.

The interhemispheric transfer theory can motivate the prediction that left-handers should show an advantage in divergent thinking because left-handers tend to show more diffuse functional brain lateralization than right-handers, in general. Although handedness is only weakly associated with the direction of language dominance, left-handers tend to have more bilateral activity supporting language (Somers et al., 2015) and supporting visuospatial processes that are typically right-lateralized in right-handers (Hellige et al., 1994). Left-handers' greater bilateral distribution of function may result in greater interhemispheric communication. As evidence for this suggestion, compared with right-handers, left-handers show faster reaction times when responding to visual hemifield stimuli with the hand controlled by the contralateral hemisphere (Cherbuin & Brinkman, 2006). Anatomically, left-handers may tend to have thicker corpus callosi than right-handers (e.g., Witelson, 1985, 1989; see Budisavljevic et al., 2021, for a review). Although recent evidence, including a meta-analysis (Westerhausen & Papadatou-Pastou, 2022) and a study in a large sample of Human Connectome Project data (Raaf & Westerhausen, 2023) has challenged this finding, in principle, higher interhemispheric connectivity in left-handers could reflect higher potential for interhemispheric transfer. Additionally, common activities like writing may involve more interhemispheric transfer in left-handers. In right-handers, both linguistic representations and dominant-hand motor control are co-lateralized to the left hemisphere, but in left-handers these functions are lateralized to different hemispheres and must be integrated (given that most left-handers have left-hemisphere language dominance; Somers et al., 2015). Therefore, systematic differences in the motor experiences of left- and right-handers could lead to differing amounts of interhemispheric transfer, independent of any handedness-linked structural differences.

Although mixed-handers may not have as diffuse functional lateralization as strong left-handers do (Somers et al., 2015), there are independent reasons to predict that they may have higher interhemispheric transfer. Mixed-handers routinely use both hands for fine motor actions, often in bimanually coordinated movement. For example, mixed-handers are more likely to play instruments that require simultaneous fine motor coordination of both hands, such as the piano (Christman, 1993). This differential experience with fine bimanual coordination could result in increased hemispheric connectivity over the course of development (Witelson, 1985). Therefore, in both left- and mixed-handers, increased hemispheric connectivity could facilitate the integration of distantly related ideas, resulting in an advantage in divergent thinking.

The origins of handedness and its relation to brain organization

The evolutionary causes of handedness remain uncertain. In one family of proposals, when left-handedness is rare in a population, it may confer a surprise advantage in fighting, and a countervailing health cost (Raymond et al., 1996) or risk of death from sharp weapons due to the position of the heart (Larsson et al., 2023) may lower the frequency of left-handedness.

However, these proposals are speculative, and difficult to test. The genetic and developmental causes of handedness are also not well understood (see Porac, 2016, for a review), though hand preference can be predicted from behavior in the womb (Hepper, 2013). Historically, handedness was believed to be linked to dramatic differences in brain organization, starting in early development. More recent studies have found that handedness is only weakly associated with asymmetries in brain organization such as language dominance (Packheiser et al., 2020; Somers et al., 2015), although left-handers may have relatively more functionally diffuse organization of language. While early differences in brain organization have been invoked as potential causes of left- or mixed-hander creativity (e.g., Coren, 1995), the potential mechanisms for how handedness might shape creativity proposed in the present paper depend on the fact that left- and mixed-handers have systematically different motor experience, which can shape the brain over a lifetime—not that brain organization is fundamentally different in right-and left-handers.

Both the right hemisphere and interhemispheric transfer theories offer motivated predictions that left- or mixed-handers might be better at divergent thinking than right-handers. Plausibly, this cognitive advantage could lead to a prevalence of left-handers in creative fields. Below, we evaluate the empirical evidence in support of these predictions: Do left-handers show an advantage in laboratory tests of divergent thinking, and are they overrepresented in professions that rely on creativity?

Handedness and laboratory tests of divergent thinking

Links between handedness and creative thinking have been tested most often using three tasks: the Alternate Uses Test (AUT; Christensen et al., 1960), the Remote Associates Test (RAT; Mednick, 1962), and the Torrance Tests of Creative Thinking (TTCT; Torrance & Ball, 1984). The AUT and TTCT are divergent thinking tests and most directly measure participants' potential to generate ideas

(Runco & Acar, 2012). The RAT is typically considered to be a test of convergent thinking, as it requires participants to converge on a correct answer to each problem. However, performance on all three tests likely involves some degree of both divergent and convergent thinking, to accomplish both idea generation and evaluation (Runco, 2023). These three tests are united in that they are some of the most popular laboratory tests of the potential for creative thinking (Runco, 2023; Said-Metwaly et al., 2017), and that they have all been cited as evidence that left- or mixed-handers may have greater creative abilities than right-handers (e.g., Heilman, 2021; Lindell, 2011; Prichard et al., 2013; Runco, 2023), or that hand action is linked to creativity (Goldstein et al., 2010; Turner et al., 2017).

The AUT (Christensen et al., 1960) assesses participants' ability to come up with original uses for a common object, such as a brick. Participants are given a time limit and asked to come up with as many original uses as they can; they are typically scored on "Fluency" (the number of uses they come up with) and "Originality" (the novelty of the uses they come up with). Originality can be scored relative to the responses of other participants in the sample, or compared with a normative sample. "Fluency" and "Originality" most directly assess participants' potential for idea generation, but some degree of evaluation is also required to constrain responses to ideas that meet a minimum level of appropriateness. Participants may also be scored on flexibility (the diversity of the participant's responses), elaboration (the level of detail in their responses), and appropriateness (the usefulness of the participant's responses).

In the RAT (Mednick, 1962), participants are shown a list of two or three cue words and asked to come up with a word that connects them. For example, the cue words "cookies/heart/sixteen" are connected by the target word "sweet." The target word may be related to the cues in multiple ways: for example, "sweet" is semantically associated with "cookies," associated with "heart" in the compound word "sweetheart," and associated with "sixteen" in the phrase "sweet sixteen." To find these connections, participants must make "semantic leaps" (Coulson, 2001), considering different possible senses of each word, and different types of relations between words. In one revised version of the RAT (Bowden & Jung-Beeman, 2003), only compound word associates (like "sweet + heart") are used. To successfully complete either version of the task, participants must search for concepts that are distantly associated with the cues, and correctly choose candidates that could meaningfully be added to every cue; as such, this task involves both convergent and divergent thinking. Participants are typically scored on the number of correct connecting words they can come up with in a given time limit.

The TTCT (Torrance & Ball, 1984) comprise two sections: "Verbal" and "Figural." The Verbal section includes a version of the AUT, as well as other verbal divergent-thinking tasks, including a "product improvement" task, in which participants write down as many ways they can think of to improve a described product. Similar to the AUT, participants can be scored on Fluency (the number of responses they produce within a time limit) and Originality (the novelty of their responses). Participants can also be scored on flexibility (the diversity of the participant's responses), and, on the figural task, elaboration (the level of detail of the drawn responses).

Meta-analysis: Handedness and divergent thinking

To assess whether available evidence supports the proposal that left- or mixed-handers show an advantage in divergent thinking over right-handers, we conducted a meta-analysis of studies reporting effects of handedness on the AUT, RAT, and Torrance Tests. We aimed to find and compile all available data on differences in performance on these three tasks as a function of direction (right vs. left) or degree (strong vs. mixed) of handedness.

Transparency and openness

We followed MARS guidelines for meta-analytic reporting (Appelbaum et al., 2018) for the meta-analysis of divergent thinking reported below. Overall, although our conclusions are supported by meta-analyses, we also used other methods (e.g., qualitative analysis, reanalysis of existing data sets). Therefore, we diverged from the MARS guidelines in two ways: We did not include the term "meta-analysis" in the title or focus on meta-analytic methods in the abstract. Further deviations from MARS guidelines are described below, where we report a meta-analysis of creative professions. Although we followed the MARS guidelines (Appelbaum et al., 2018) rather than PRISMA (Moher et al., 2009) in our meta-analytic reporting, we include a PRISMA-style flowchart to illustrate how studies were selected (Fig. 1). All meta-analytic data, analysis code, and research materials are available online (https://osf.io/xhpjy). Data were analyzed using R (Version 4.0.0; R Core Team, 2023) and the *meta* package (Version 5.2–0; Balduzzi et al., 2019). This review project was not preregistered.

Inclusion criteria. Studies were screened using the following inclusion criteria:

1. **Divergent-thinking tasks**. The article must have reported descriptive or inferential statistics using any behavioral measure from either the AUT, the RAT, or the TTCT.

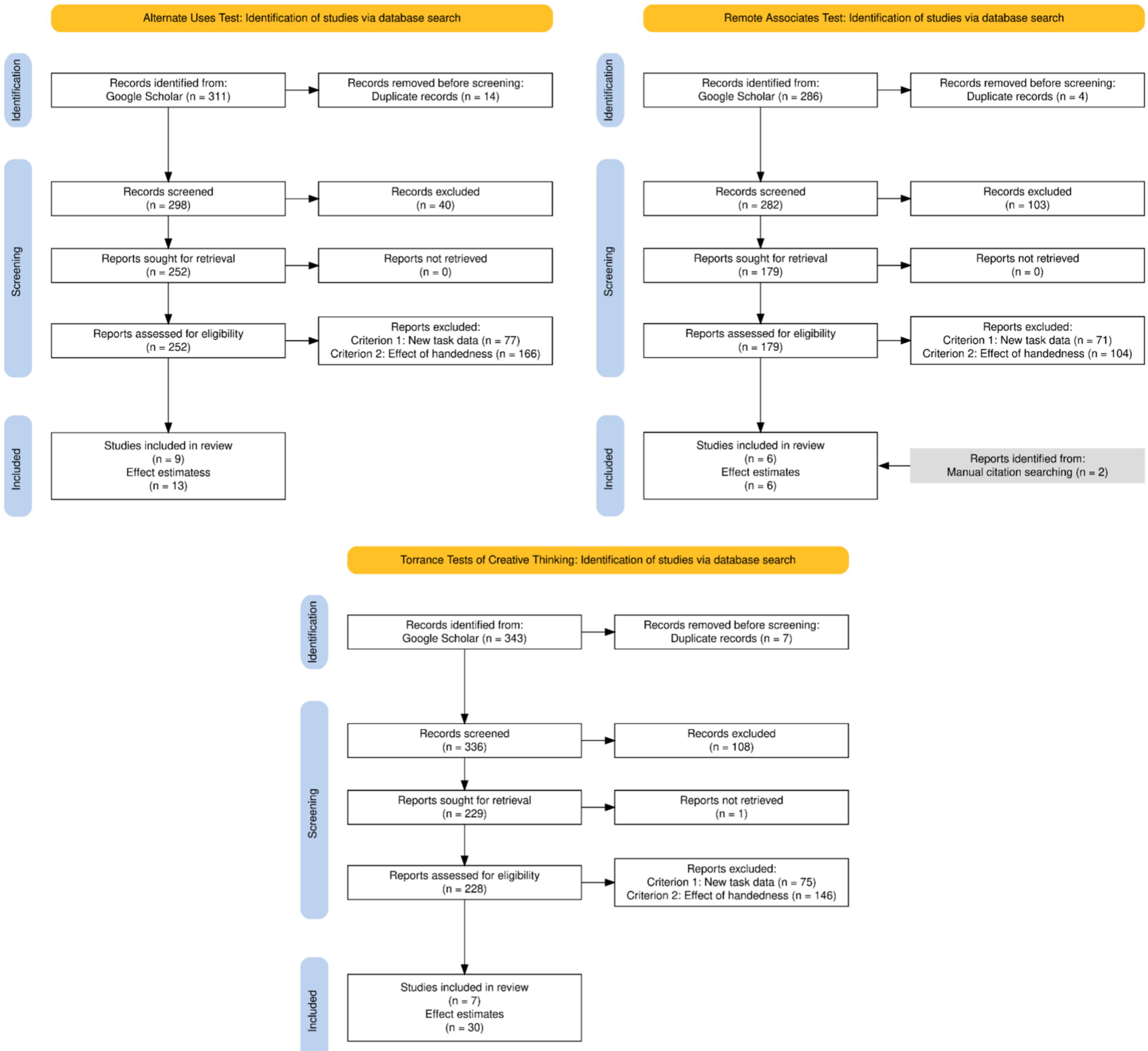

Fig. 1 Study selection flowchart (divergent thinking meta-analyses)

2. **Handedness**. The article must have reported (a) an estimate of difference between handedness groups, with at least three participants in the smaller handedness group, or (b) a correlation between degree (or direction) of handedness and any measure of divergent thinking as specified in Criterion 1, as well as a measure of error. Or, the article must have reported sufficient information to calculate such a difference or correlation, and its standard error. "Handedness groups" could comprise left-handers and right-handers, or mixed-handers and strong-handers, using any measure of handedness, as long as the smallest group included at least three participants. Correlations could be between degree or direction of handedness and any measure of divergent thinking from Criterion 1.
3. **Populations**. The relevant comparison or correlation could be between or within any group of healthy children, adolescents, or adults, as long as the relevant between-group statistics did not compare qualitatively different groups.
4. **Year, language, and publication type**. Any study published after 1900 was considered for inclusion. Because of the language abilities of the authors, only studies available in English were included. Both peer-reviewed journal articles and publicly available theses and dissertations were included.

Selection strategy

Candidate studies were identified through a systematic literature search, using the databases Google Scholar and PsychInfo. Google Scholar was chosen, in part, so that our search would include gray literature, including theses and dissertations. To identify candidate studies that administered the AUT, we used the search terms *"('alternate uses task' OR 'alternative uses task' OR 'unusual uses task' OR 'alternate uses test' OR 'alternative uses test' OR 'unusual uses test') AND (handedness OR left-handed OR 'left-hander' OR inconsistent-handed OR 'inconsistent hander')."* For the RAT, we used the search terms *"'remote associates test' AND (handedness OR left-handed OR 'left-hander' OR inconsistent-handed OR 'inconsistent hander')."* For the Torrance Tests, we used the search terms *"'torrance tests' AND (handedness OR left-handed OR 'left-hander' OR inconsistent-handed OR 'inconsistent hander')."* Abstracts were screened for uniqueness and potential relevance, and potentially relevant articles were examined for whether they reported a relevant test of divergent thinking (Criterion 1) and provided enough information to extract an effect of handedness (Criterion 2).

Additional relevant studies were identified through manual review of the literature, starting by searching citations to and from the seed studies Lindell (2011), Prichard et al. (2013), and Fritsche and Lindell (2019). Manual literature review was conducted by author O.M., a PhD student. Two raters, author O.M. and author S.Z. (a PhD student), reviewed the studies of the systematic literature search for inclusion criteria. First, both raters coded a random set of 10 studies from the systematic search, discussed, and resolved any disagreements by consensus. Each rater coded the remaining studies independently. The two raters then compared their coding of all studies, and recorded any discrepancies, which were then resolved by consensus.

Effect-size calculation

Included studies could report any statistic of a difference between handedness groups, or correlation between degree or direction of handedness and divergent thinking. Cohen's *D*, correlation coefficients, and standardized regression coefficients, from models with or without moderators, were all accepted for inclusion, even though some estimates could not be (and were not) pooled with others. When multiple statistics were reported or could be calculated for the same sample in a single article, in order to maximize the number of studies that could be pooled, (1) Cohen's *D* and Pearson's rho were preferred, and (2) simple effect estimates were preferred to complex effects. For example, if both the Cohen's *D* for a test between groups with no moderators, and a Cohen's *D* for a linear model comparing groups with moderators, were available, the estimate of the unmoderated effect was used. When both descriptive and inferential statistics were reported for a given comparison, descriptive statistics were used to calculate effect estimates. For example, if a study reported the means, sample sizes, and standard deviations for two groups, as well as the results of a *t* test comparing the two groups, the descriptive statistics were used to calculate Cohen's *D* between the groups, instead of the reported inferential statistics. The formulas and code used to extract effects for each study can be found in the repository (https://osf.io/xhpjy).

When a study provided enough information to do so, estimates of differences between both right- and left-handers, and strong and mixed-handers, were extracted. Similarly, correlations between degree of handedness and divergent thinking, and between direction of handedness and divergent thinking, were both extracted whenever possible. Additionally, when an article reported enough information to find both an estimate of group difference and an estimate of correlation, both were extracted. Across studies, different methods were used for measuring handedness, and for binning participants as right- versus left-handed, or strong- versus mixed-handed. When possible, we extracted effect sizes for a right- versus left-hander comparison, and a strong versus mixed hander comparison, as well as correlation estimates using both degree and direction of handedness, for each reported sample.

Handedness group coding

To extract comparisons for right- versus left-handers, we sought to categorize groups in a way that would best approximate a zero-split on a laterality quotient of handedness (e.g., Oldfield, 1971). For example, if a study binned participants as "right" versus "non-right" handers, where right-handers were those who got the maximally right-handed score on the Edinburgh Handedness Inventory (EHI), and also reported "writing hand," then "writing hand" was preferred to categorize right- versus left-handers. When participants were categorized in three bins, such as "right," "left," and "mixed," the comparison groups "right" and "left" were used.

For strong- versus mixed-hander comparisons, we sought to categorize groups to approximate the number of participants who would endorse using the same hand for every item on a handedness questionnaire, versus those who would endorse using a different hand for one or more items. For example, if the number of participants with the maximum and minimum scores on the EHI, and the number with intermediate scores was reported or could be reconstructed from a figure, those numbers were used. If a study included a comparison between strong and mixed-handers, but none of the strong-handers were left-handed, the study was still considered as a comparison between "strong" and "mixed" handers (the sole study meeting this criteria was Shobe et al., 2009). Because a high proportion of strong-handers are right-handed, this comparison can be considered a useful approximation of strong versus mixed handedness. For correlations, measures of motor asymmetry (e.g., the absolute difference in the number of finger taps a person can make with each hand in one minute) were coded as reflecting strong versus mixed handedness. However, effect estimates that measured motor asymmetry were not pooled together with studies that measured hand preference (the sole study that met inclusion criteria and used a motor asymmetry measure was van der Feen et al., 2020). For information about how handedness groups were defined in each included study, see Table 2 (Note 2).

Effect-size pooling

Pooled effect sizes were estimated for each effect-size type, task, and measure, for both right- versus left- and strong- versus mixed-hander comparisons. In some cases, only one study yielded a particular effect-size type: these studies' effect sizes were listed separately in summary tables and not pooled with any other studies. Studies that reported finding no significant effect or correlation for a given effect-size type but did not report relevant statistics were not considered in pooled estimates or shown in summary figures but were noted and considered in qualitative interpretation.

When effect-size pools included at least three studies, mixed-effects models with study as a random effect were run to account for heterogeneity between studies. Fixed effect models were also run for comparison. When effect-size pools included only two studies, only fixed-effect models were used, because random effects could not be meaningfully calculated. Mixed and fixed-effects model analyses with inverse variance weighting were done using the R package *meta* (Version 5.2–0; Balduzzi et al., 2019).

Publication bias

Because meta-analytic pools had relatively few effect estimates for each effect-size type, publication bias could not be assessed quantitatively.

Results

Search results

Database searches were conducted for the three tasks of interest: the AUT, the RAT, and the TTCT. These searches yielded a total of 17 included studies with a total of 49 effect sizes (across all tasks, measures and effect size types). See Table 2 for a summary of included studies, and Fig. 1 for flow charts illustrating how studies were selected.

Alternate uses test search results

For the AUT, our database search yielded 311 results, 297 of them unique. Of these, 252 titles and abstracts were screened as potentially relevant. Of these, 175 presented new experimental AUT data, and nine studies reported an effect size of handedness on AUT performance (correlation or group difference), or provided enough information to calculate such an effect size. These nine studies yielded 13 effect sizes across measures of Fluency and Originality.

Remote associates test search results

For the RAT, our database search yielded 286 results, 282 of them unique. Of these, 179 titles and abstracts were screened as potentially relevant. Of these, 108 presented new experimental RAT data, and four studies reported an effect size of handedness on RAT performance (correlation or group difference), or provided enough information to calculate such an effect size. An additional two studies were identified through manual citation review, yielding six included studies with six effect sizes.

Torrance Tests search results

For the TTCT, our database search yielded 343 results, 336 unique. Of these, 229 titles and abstracts were screened as potentially relevant. Of these, 153 presented new experimental Torrance Tests data, and seven reported an effect size of handedness on Torrance Tests performance (correlation or group difference), or provided enough information to calculate such an effect size. These seven studies yielded 19 effect sizes for the Figural subtest (across measures of Fluency, Originality, Flexibility, and Elaboration), and 11 effect sizes for the Verbal subtest (across measures of Fluency, Originality, and Flexibility).

Intercoder reliability

For the RAT search, the two raters' coding agreed on whether each study met inclusion criteria for 286/287 search results (99.7%), leaving one discrepancy: Wrightson (2019) was coded by S.Z. as not relevant and by O.M. as relevant, but reporting only a null result, without effect size or statistics that could be used to calculate one. However, while this study reported administering versions of the RAT, AUT, and TTCT, the authors did not report whether they found a null result for any of these tasks in particular ("handedness only had one significant relationship in a nonhypothesized direction

Table 2 Divergent thinking meta-analysis study characteristics

Study	Sample size	Handed- ness measure	Task [1]	Measures	Handedness groups [2]	Extracted effect(s)	Results (categorical)	Results (continuous)
Jones et al. (2011)	43 right, 21 left-handers	EHI [3]	AUT	Fluency	R/L (0-split)	D: Calculated from reported means, *SD*s, *N*s	Left advantage	-
			RAT	Problems solved out of 20, untimed	…	…	Null (Est. favors right)	-
Coren (1995)	556 participants [4]	LPI [5]	AUT	Fluency	R/L (0-split)	D: Calculated from reported means, *SD*s, *N*s	Null (Est. favors right)	-
					S/M ("strong right" and "strong left" are compared with "mixed right" and "mixed left")	…	Null (Est. favors strong)	-
Felton (2017) *[PhD Thesis]*	151 participants	EHI	AUT	Fluency	S/M (median split on absolute value scores)	D: Calculated from reported means, *SD*s, *N*s	Null (Est. favors strong)	-
				Originality	…	…	Null (Est. favors strong)	-
			RAT	Problems solved out of 21, untimed	…	…	Null (Est. favors strong)	-
Folley (2006) *[PhD Thesis]*	51 right-handers	EHI	AUT	Fluency	R/L (continuous)	Rho: Reported; CI calculated from *N*	-	Null (Est. favors left)
Everatt et al. (1999)	36 participants	EHI	AUT	Fluency	R/L (continuous)	Rho: Reported; CI calculated from *N*	-	Null (Est. favors left)
			TTCT-F	Fluency	…	Rho: Reported; CI calculated from *n*	-	Null (Est. favors left)
Zickert et al., (2018a, 2018b)	3205 right, 5894 left-handers (0-split)	EHI	AUT	Fluency	R/L (continuous; 0-split)	D, Rho: Calculated from raw data	Right advantage	Right advantage
	3152 strong left, 2697 mixed left, 1889 mixed right, 1316 strong right-handers				S/M (continuous, cut at ± 20/100)	…	Mixed advantage (highest scores for moderate right-handers)	Mixed advantage (highest scores for moderate right-handers)
				Originality	R/L (continuous; 0-split)	…	Right advantage	Right advantage
					S/M (continuous, cut at ± 20/100)	…	Mixed advantage (highest scores for moderate right-handers)	Mixed advantage (highest scores for moderate right-handers)

Table 2 (continued)

Study	Sample size	Handed- ness measure	Task [1]	Measures	Handedness groups [2]	Extracted effect(s)	Results (categorical)	Results (continuous)
Shobe et al. (2009)	32 strong right, 32 mixed-handers [6]	EHI	AUT	Fluency	S/M (median split on absolute value scores)	D: Calculated from reported *F* test	Null (Est. favors mixed)	—
				Originality	…	…	Mixed advantage	—
				Flexibility	…	…	Mixed advantage	—
				Elaboration	…	…	Mixed advantage	—
				Appropriateness	…	…	Mixed advantage	—
Turner (2016) *[PhD Thesis]*	48 strong, 48 mixed-handers	EHI	AUT	Fluency	S/M (cut at ± 75/100)	D: Calculated from reported means, *SD*s, *N*s	Null (Est. favors strong)	—
				Originality	…	…	Null (Est. favors strong)	—
				Flexibility	…	…	Null (Est. favors strong)	—
				Elaboration	…	…	Null (Est. favors strong)	—
				Appropriateness	…	…	Null (Est. favors strong)	—
			RAT	Problems solved in 5 min	S/M (cut at ± 75/100)	…	Null (Est. favors strong)	—
van der Feen et al. (2020)	8353 participants, ~ 50% left dominant	Tapping asym	AUT	Fluency	R/L (continuous) [7]	Beta: Reported in multiple regression model including sex, age squared, and squared tapping asymmetry (a measure of degree of handedness) as covariates	—	Right advantage
				Originality	…		—	Right advantage
Turner et al. (2017)	43 strong right, 17 non-right	EHI	RAT	Problems solved in 15 min	R/L (continuous)	Rho: reported; CI calculated from *N*	—	Null (Est. favors right)
Katz (1980)	70 right, 30 left-handers	Crovitz & Zener [8]	RAT	Unreported	R/L (continuous) [9]	Rho: reported; CI calculated from *N*	Null (Est. favors right)	—
			TTCT-F	Fluency	…	…	Null (Est. favors right)	—
				Originality	…	…	Null (Est. favors right)	—
				Flexibility	…	…	Null (Est. favors right)	—

Table 2 (continued)

Study	Sample size	Handed- ness measure	Task [1]	Measures	Handedness groups [2]	Extracted effect(s)	Results (categorical)	Results (continuous)
				Elaboration	…	…	Null (Est. favors right)	—
			TTCT-V	Fluency	…	…	Null (Est. favors left)	—
				Originality	…	…	Null (Est. favors right)	—
				Flexibility	…	…	Null (Est. favors let)	—
Hattie and Fitzgerald (1983)	52 strong right, 22 mixed, 29 strong left-handers	EHI	RAT	Unreported	R/L (continuous) [10]	Rho: reported; CI calculated from *N*	—	Null (Est. favors right)
			TTCT-F	Fluency	…	…	—	Null (Est. favors right)
				Originality	…	…	—	Null (Est. favors right)
				Flexibility	…	…	—	Null (Est. favors right)
				Elaboration	…	…	—	Null (Est. favors right)
			TTCT-V	Fluency	…	…	—	Null (Est. favors neither)
				Originality	…	…	—	Null (Est. favors left)
				Flexibility	…	…	—	Null (Est. favors right)
Burke et al. (1989)	12 right, 12 left-handers	Self-ID	TTCT-F	Fluency	R/L (binary self-ID)	D: Calculated from reported means, *SD*s, *N*s	Null (Est. favors left)	—
				Originality	…	…	Null (Est. favors left)	—
				Flexibility	…	…	Null (Est. favors left)	—
				Elaboration	…	…	Null (Est. favors left)	—
			TTCT-V	Fluency	R/L (binary self-ID)	…	Null (Est. favors right)	—
				Originality	…	…	Null (Est. favors left)	—
				Flexibility	…	…	Null (Est. favors left)	—
Newland (1981)	96 right, 96 left-handers	BNHI [11]	TTCT-F	Fluency	R/L (cut at $\pm$4/24)	D: Calculated from reported means, *SD*s, *N*s	Left advantage	—
				Originality	…	…	Left advantage	—
				Flexibility	…	…	Left advantage	—
				Elaboration	…	…	Left advantage	—

Table 2 (continued)

Study	Sample size	Handed- ness measure	Task [1]	Measures	Handedness groups [2]	Extracted effect(s)	Results (categorical)	Results (continuous)
Stewart and Clayson (1980)	15 left, 15 right-handers	Harris Tests [12]	TTCT-F	Originality	R/L (cut at ±4/24)	D (partial): Calculated from F-test; model included handedness and age as covariates	Left advantage	—
				Elaboration	…		Left advantage	—
Falletta (1986) *[EdD thesis]*	28 left, 28 right-handers	Self-ID	TTCT-F	Originality	R/L (binary self-ID)	D: Calculated from reported means, *SD*s, *N*s	Null (Est. favors right)	—
				Elaboration	…	…	Null (Est. favors left)	—
Bosch (2013) *[PhD thesis]*	51 participants	EHI	TTCT-F	Originality	R/L (continuous)	Rho: reported; CI calculated from N	—	Null (Est. favors right)
			TTCT-V	Fluency	…	…	—	Null (Est. favors neither)
				Originality	…	…	—	Null. (Est. favors right)

[1] "AUT": Alternate Uses Task; "RAT": Remote Associates Test"; "TTCT-F": Torrance Tests of Creative Thinking (Figural); "TTCT-V": Torrance Tests of Creative Thinking (Verbal)

[2] "R/L": Comparison between right- and left-handers; "S/M": comparison between strong right- and left-handers versus mixed-handers. When available from reported information, or enough information was given to create left/right and strong/mixed categories following the procedure described in the Method section, the numerical cutoffs used to bin handedness groups are described (e.g., "S/M (cut at ± 75/100)" means that participants with a score greater than 75, or less than − 75, in a 100-point hand preferences scale, were classified as strong-handers, and those in between were classified as mixed-handers. "0 split": Participants with handedness inventory scores less than zero are considered left-handed; those with scores greater than zero are considered right-handed. "Median split": Left- and right-handedness were binned on either side of the sample median.) If numerical criteria are unknown, the categories used in the original article are described (e.g., Coren, 1995, reports groups of "strong right," "strong left," "mixed right," and mixed left," but numerical cutoffs are unknown)

[3] Edinburgh Handedness Inventory (Oldfield, 1971), a hand-preference questionnaire that yields a continuous measure of hand preference

[4] Coren (1995) presented group means and standard deviations for strong right-, moderate right-, moderate left-, and strong left-handers. The number of participants in each handedness group was not reported. To calculate effect sizes and confidence intervals, we assumed an equal number of participants in each group. This assumption is plausible because standard deviations were similar between strong right- and strong left-handers, and between moderate right- and moderate left-handers

[5] Lateral Preference Inventory, a four-item score developed by Coren. Assesses self-reported preference for 4 activities (throwing a ball, drawing, erasing, playing cards), each on a 3-point scale

[6] Shobe et al. (2009) included 62 participants, 30 in a condition where participants completed a bilateral movement intervention, and 32 in a control condition. Only the control participants are considered in the present meta-analysis because the bilateral movement intervention could plausibly influence divergent thinking differently depending on handedness. The group of non-righthanders was classified as "mixed" handed because it only included one strong left-hander. This study also measured Flexibility, Elaboration, and Appropriateness, but these results were not considered in meta-analysis because no other included AUT study reported them

[7] Van der Feen et al. (2020) also reported null effects of degree of handedness (tapping asymmetry squared) on Fluency and Originality. The authors reported p values for these tests, but not effect sizes or statistics that could be used to calculate them

[8] A continuous measure assessing self-reported hand preference for 18 activities, each on a 9-point scale

[9] Katz (1980) also reported finding a null effect for right- versus left-handers ("the two handedness groups did not differ on any of the measures of creativity"), but did not report statistics

[10] Hattie and Fitzgerald (1983) also reported finding a null effect for strong versus mixed-handers ("the three handedness groups did not differ on any of the measures of creativity"), but did not report statistics

[11] Briggs and Nebes Handedness Inventory, a continuous measure assessing self-reported hand preference for 12 items, each on a 5-point scale

[12] A set of tests of hand dominance including knowledge of right and left, hand preferences, simultaneous writing, handwriting, tapping, and dealing cards. Matched self-reported handedness

[right-handedness predicted better outcomes on the creative cognitive variables]," Wrightson, 2019). By consensus, this study was coded as not meeting inclusion criteria. For the AUT search, raters' coding agreed for 307/310 search results (99.0%), leaving three discrepancies: (1) Wrightson (2019; already described); (2) Mendes (2019) was coded by O.M. as not relevant but by S.Z. as reporting relevant statistics. This study reported collecting handedness but did not report tests of the effect of handedness on divergent thinking, or include handedness in their data repository; therefore, by consensus, this study was coded as not including relevant statistics. (3) Ross (2008), an undergraduate thesis, was coded by S.Z. as relevant but by O.M. as a duplicate. This study reported the same sample as the published article, Shobe et al. (2009), which met inclusion criteria. Therefore, by consensus, Ross (2008) was coded as a duplicate. For the TTCT search, raters' coding agreed on 338/342 search results (98.8%), leaving four discrepancies: (1) Wrightson (2019; already described); (2) Sampedro et al. (2020) was coded by S.Z. as relevant but by O.M. as not meeting inclusion criteria. This study used a clinical sample of participants with schizophrenia, and by consensus, did not meet inclusion Criterion 4, "any group of healthy children, adolescents, or adults." (3) Sampedro et al. (2021) was coded by S.Z. as relevant but by O.M. as a duplicate. This study included a subset of the participants of Sampedro et al. (2020); therefore, by consensus, it was coded as a duplicate. (4) Bosch (2013) was coded by S.Z. as not meeting inclusion Criterion 2 for handedness but by O.M. as relevant. While this study did not report the distribution of handedness in its sample, it reported a correlation between a continuous measure of handedness and a relevant measure of divergent thinking; therefore, by consensus, the study was coded as relevant.

Effect estimates and discussion

Extracted effects for each study, and pooled estimates for each effect-size type, task, and measure, for both right- versus left- and strong- versus mixed-handedness, are shown in Figs. 2, 3, 4, and 5. Included studies reported a

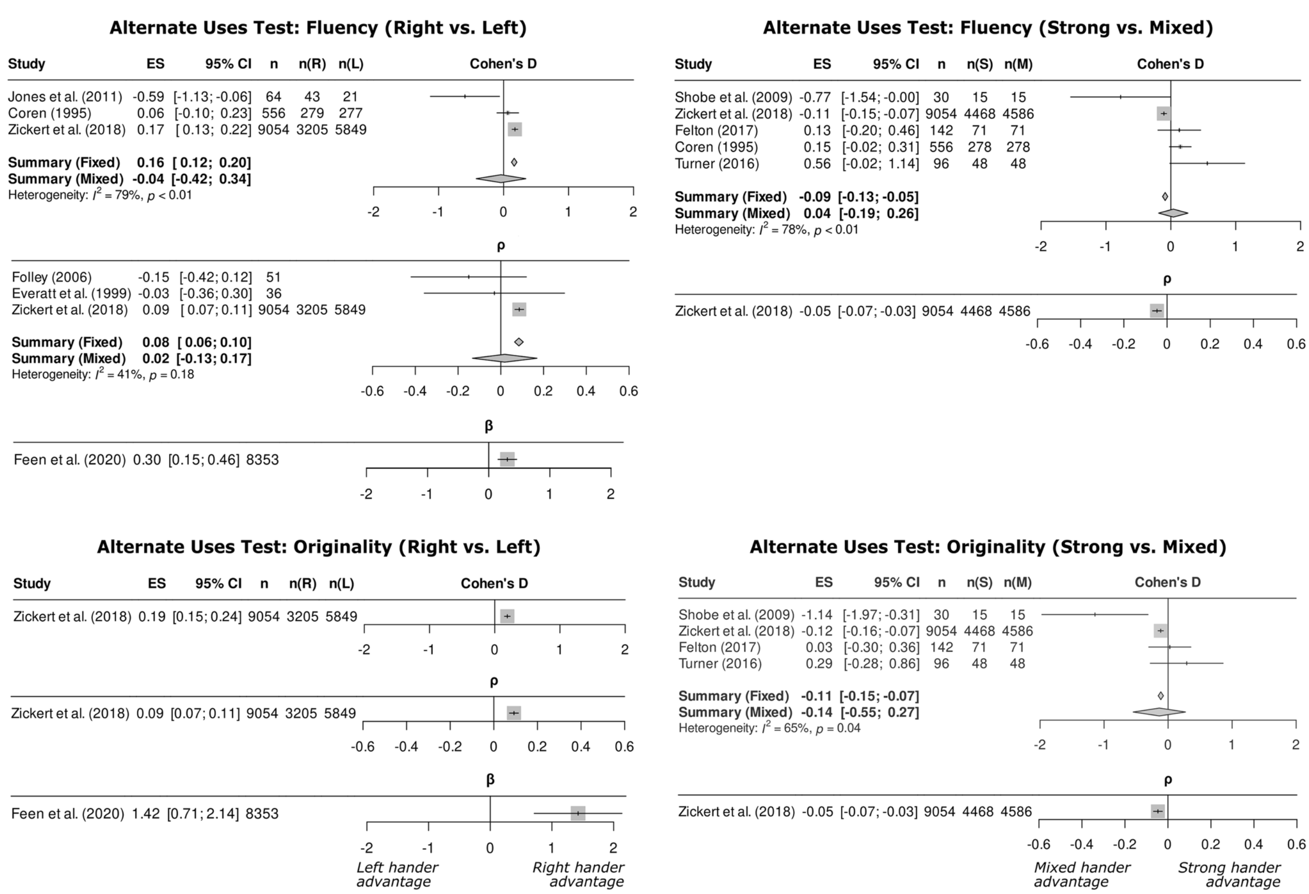

Fig. 2 Alternate Uses Test meta-analysis results

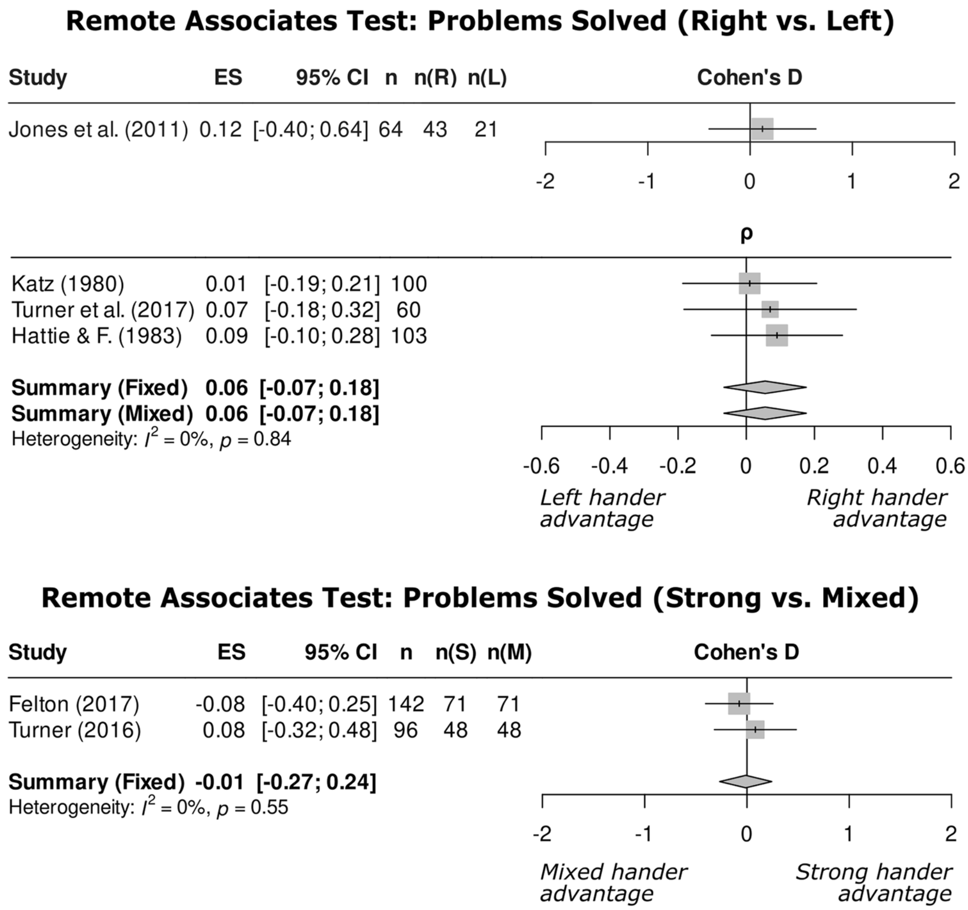

Fig. 3 Remote Associates Test meta-analysis results

heterogeneous mix of effect-size types, and in some cases effect sizes that met inclusion criteria could not be statistically pooled with effects from any other studies. For example, Stewart and Clayson (1980) reported effect sizes only for a model that included covariates, which were not identical to the models in any other studies. Accordingly, the quantitative meta-analytic results will be discussed in the context of a qualitative review of all included studies.

Alternate Uses Test

Right- versus left-handers. Fixed effect meta-analytic estimates suggest a small *right-hander* advantage in Fluency, whether handedness is measured categorically (Cohen's $D=0.16$, 95% CI [0.012, 0.20]) or continuously (rho = 0.08, 95% CI [0.06, 0.10]; see Fig. 2). These pooled estimates are driven by the largest study, Zickert et al. (2018a), which found a right-hander advantage on both Fluency and Originality in a sample of more than 3,000 right-handers and 5,000 left-handers. Analyzing the same sample as Zickert et al. (2018a), van der Feen et al. (2020) confirmed a right-hander advantage in Fluency and Originality when handedness was measured by tapping asymmetry, rather than hand preference. Only one study, Jones et al. (2011) found evidence for a left-hander advantage, in a relatively small sample ($n=43$ right-handers and 21 left-handers).

Strong versus mixed-handers. Fixed effect meta-analytic estimates find a small mixed-hander advantage for categorical handedness, in both Fluency (*Cohen's* $D=0.09$, 95% CI [0.05, 0.13]) and Originality (*Cohen's* $D=0.11$, 95% CI [0.07, 0.15]). These pooled estimates are again driven by the largest study, Zickert et al. (2018a), which found that degree of mixed handedness predicted Fluency and Originality scores. However, in their analysis of the same dataset, van der Feen et al. (2020) found a null result for the effect of mixed-handedness on divergent thinking, when handedness was measured by tapping asymmetry rather than hand preference (this null effect was not included in Fig. 2 because effect size information was not reported for this analysis).

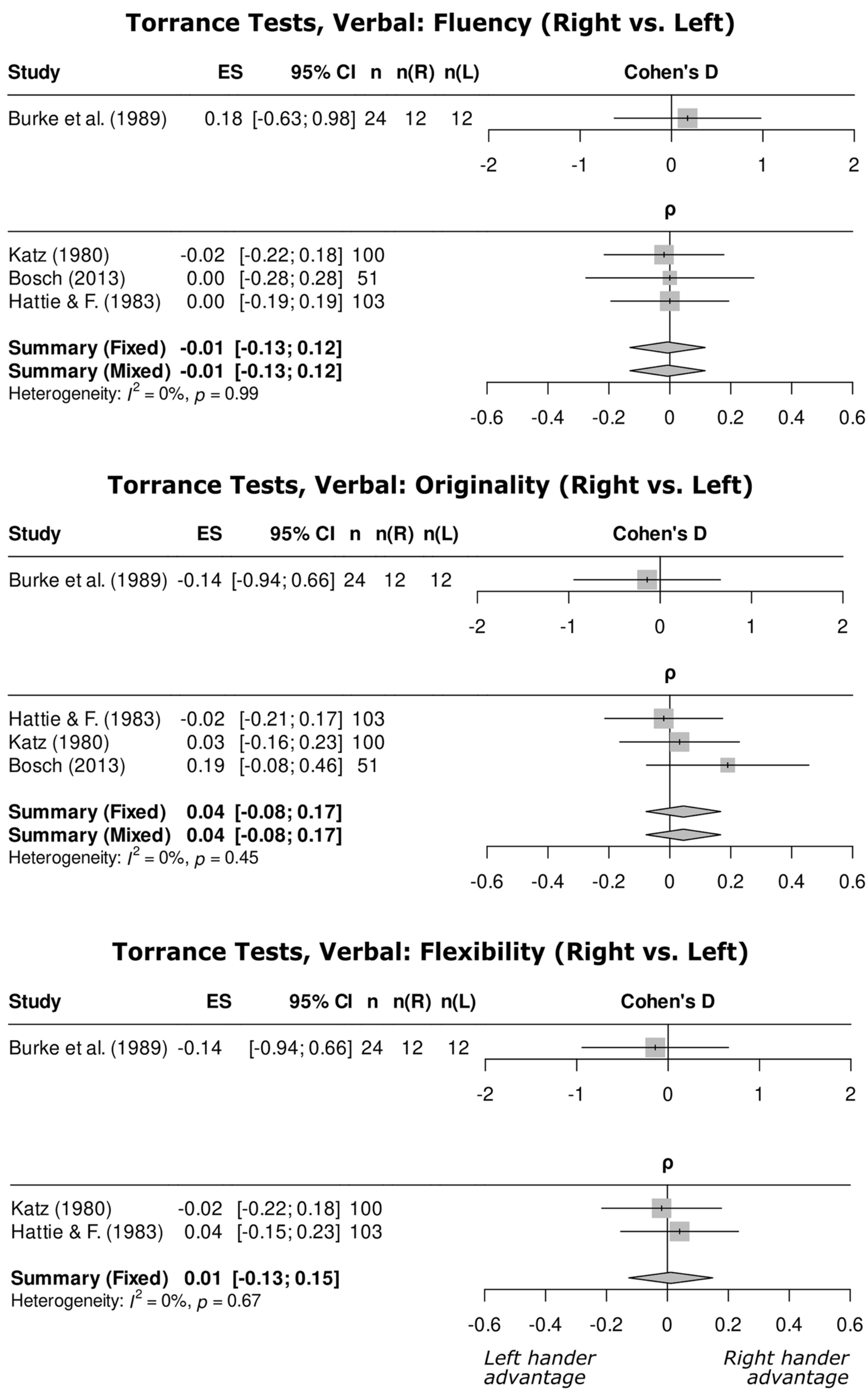

Fig. 4 Torrance Tests (Verbal) meta-analysis results

In Zickert et al.'s (2018a) study, the relationship between handedness and divergent thinking was driven by moderately right-handed participants (those with EHI scores of 5 to 15 on a scale of – 20 to 20), who showed greater divergent thinking scores than both left-handers and strong right-handers. Exploratory analysis of Zickert et al.'s (2018b) openly

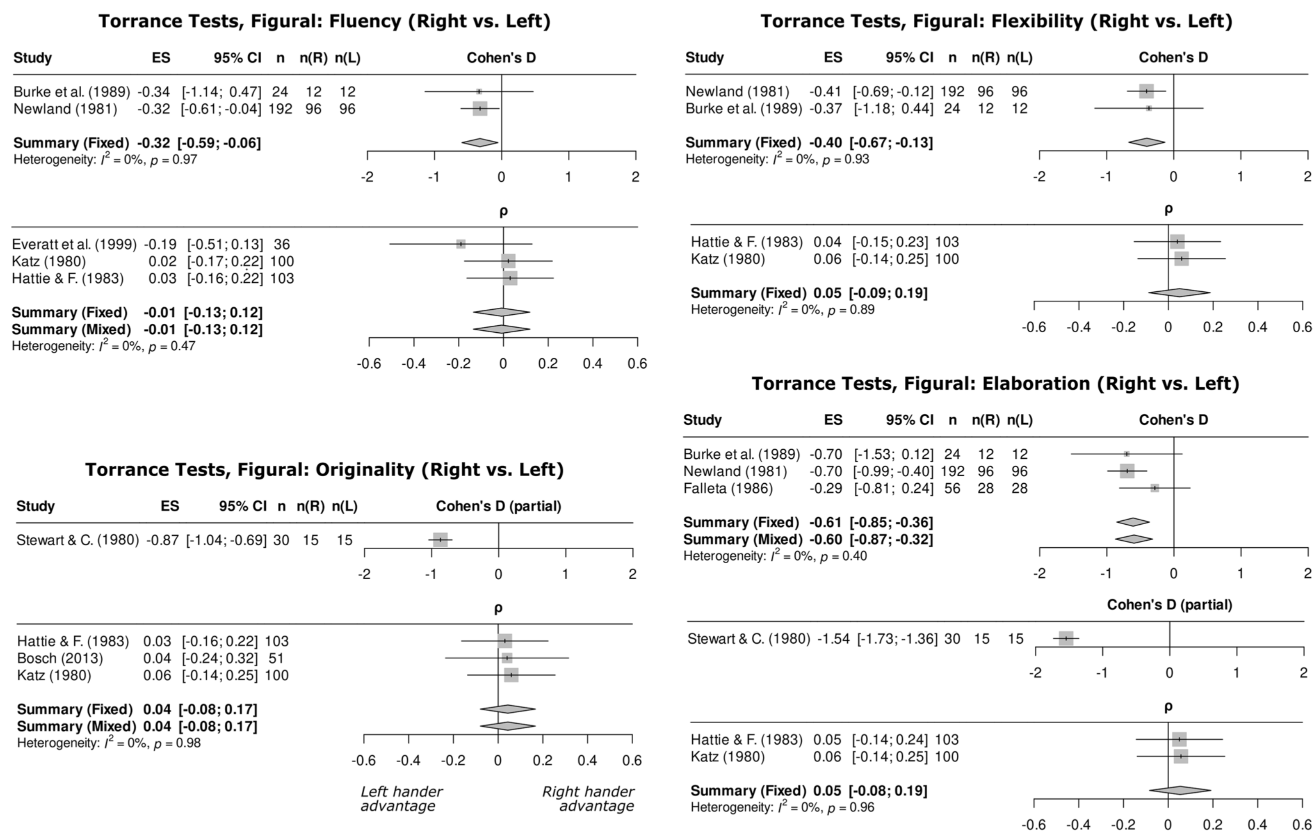

Fig. 5 Torrance Tests (Figural) meta-analysis results

available dataset confirmed that direction and degree of handedness each predict AUT performance when both are modeled as covariates. Direction of handedness predicted Fluency with a slope of 0.48 AUT ideas per 20 EHI units (95% CI [0.36, 0.60]), $t(9{,}051) = 7.64$, $p < 0.001$, on the EHI scale of − 20.

(strongly left-handed) to 20 (strongly right-handed); degree of handedness predicted Fluency with a slope of 0.31 AUT ideas per 10 EHI units (95% CI [0.12, 0.50]), $t(9{,}051) = 3.15$, $p = 0.002$, on the absolute EHI scale of 0 (*no hand preference*) to ± 20 (*strongly left- or right-handed*; see Fig. 6 for a visualization of the relationship between handedness and AUT performance in this dataset). This pattern of results is consistent with the possibility that both *right* and *mixed* handedness independently predict divergent-thinking ability; however, it is inconsistent with the claim that *left*-handedness predicts divergent thinking.

Additionally, Katz (1980) mentioned finding a null result for right- versus left-handers ("The two handedness groups did not differ on any of the measures of creativity"), but this test was not included in the meta-analysis because Katz (1980) did not report its effect size.

Remote Associates Test

Of the six studies that have tested the effect of handedness on RAT performance, not one found a significant advantage for left- or mixed-handers. Fixed-effect meta-analytic estimates are close to zero, and do not show any significant correlation between direction of handedness and RAT performance (rho = 0.06 in the direction of right-handedness predicting greater RAT performance, 95% CI [− 0.07, 0.18]), nor any group difference between strong- versus mixed-handers (Cohen's $D = -0.01$ in the direction of mixed-handedness, 95% CI [− 0.27, 0.24]; see Fig. 3).

Although the meta-analytic results are all null, we note that the point estimates for right- versus left-handers consistently favor right-handers. Together, these results provide no evidence that left- or mixed-handers have an advantage on the RAT.

Torrance Tests of Creative Thinking

Fixed effect meta-analysis finds no evidence for an effect of handedness on the Verbal Torrance Tests, in Fluency (rho = − 0.01 in the direction of left-handedness, 95% CI

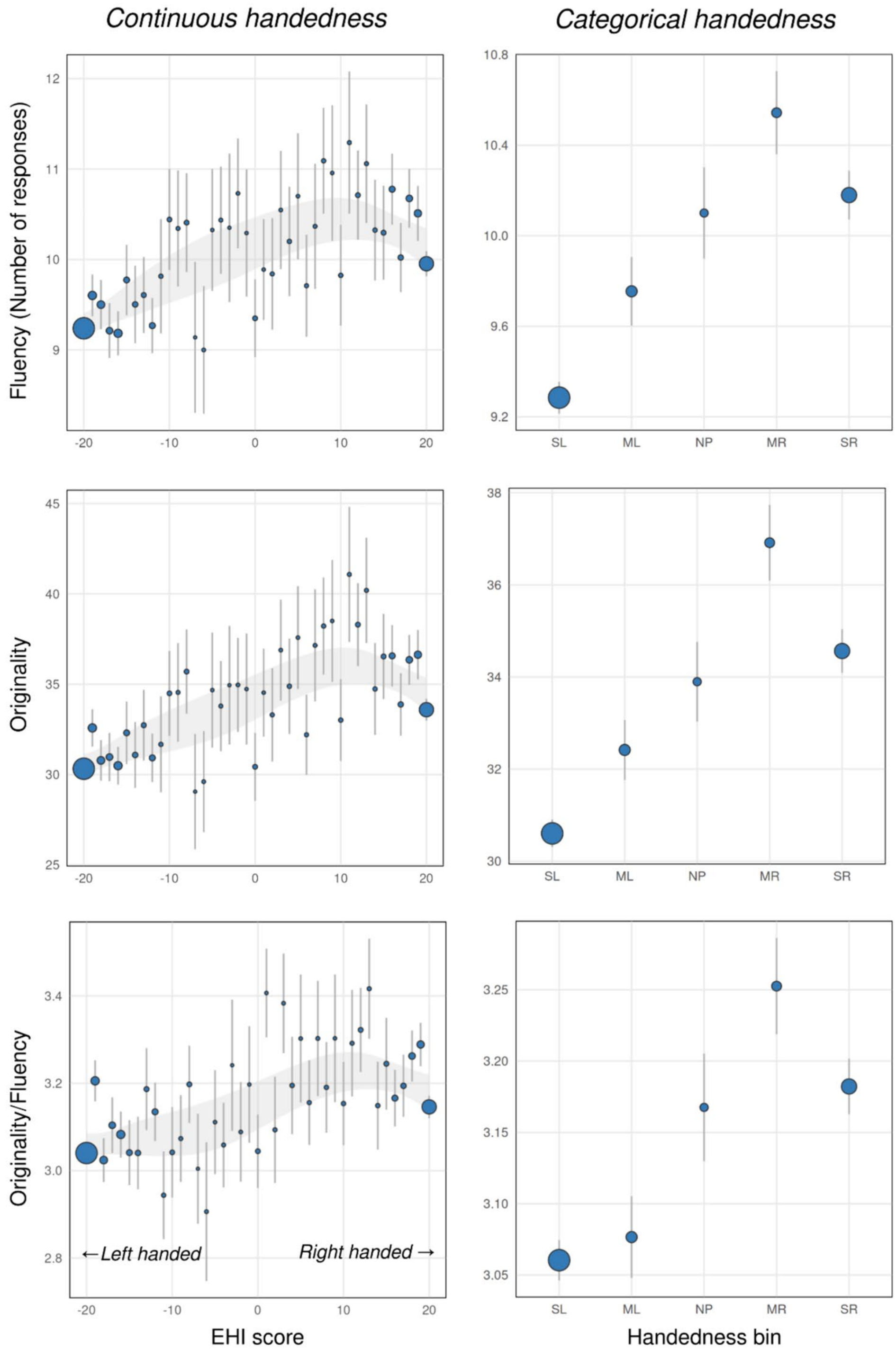

Fig. 6 Data from Zickert et al. (2018a): Relationship between handedness and AUT performance. *Note*. This figure visualizes the relationship between handedness and AUT performance in the dataset Zickert et al. (2018b), following the author's inclusion criteria as described in Zickert et al. (2018a). The left column shows the relationship between handedness (measured continuously) and AUT Fluency, Originality, and Originality divided by Fluency, with overlaid LOESS curves. The right column shows AUT scores by handedness bin, using the same bins as Zickert et al. (2018a): SL (Strong Left) = EHI − 20 to − 16; ML (Moderate Left) = EHI − 15 to − 5; NP (No Preference) = EHI − 4 to 4; MR (Moderate Right) = EHI 5 to 15; SR (Strong Right) = EHI 16 to 20. (Compare with Fig. 4b in Zickert et al., 2018a, which shows groupwise performance in a principal component score that includes AUT performance measures). Moderate right-handers show the highest AUT scores, and left-handers show the lowest

[−0.13, 0.12]), Originality (rho = 0.04 in the direction of right-handedness, 95% CI [−0.08, 0.17]), or Flexibility (rho = 0.01 in the direction of right-handedness, 95% CI [−0.13, 0.15]; see Fig. 4). No studies have reported on the effect of strong- versus mixed-handedness on the verbal Torrance Tests.

However, some pooled estimates find higher scores for left-handers in the Figural Torrance Tests. For Fluency, a pool of three correlation effects (Everatt et al., 1999; Hattie & Fitzgerald, 1983; Katz, 1980) yields a fixed-effect estimate close to zero (rho = −0.01, 95% CI [−0.13, 0.12]), suggesting no influence of handedness; but, two studies testing for group differences (Burke et al., 1989; Newland, 1981) yield an effect estimate suggesting that left-handers have an advantage in the Fluency measure (Cohen's $D = -0.32$, 95% CI [−0.59, −0.06]). The data for Originality show a similar pattern: the pool of three studies (Bosch, 2013; Hattie & Fitzgerald, 1983; Katz, 1980) testing for correlation suggests no relationship between handedness and Originality (rho = 0.04 in the direction of right-handedness, 95% CI [−0.08, 0.17]), but the pool of three studies testing group differences (Burke et al., 1989; Falletta, 1986; Newland, 1981) yields an estimate favoring left-handers (Cohen's $D = -0.53$, 95% CI [−0.78, −0.29]). A similar pattern holds for the effect of handedness on Flexibility and Elaboration (see Fig. 5). While this pattern of results is not clear-cut, overall, we find some evidence that left-handers may score higher than right-handers on the Figural—but not Verbal—Torrance Tests.

This dissociation between the Verbal and Figural Torrance Tests calls into question whether a left-hander advantage on the Figural TTCT points to any general advantage in divergent thinking. The two subtests tend to produce scores orthogonal to one another (Baer, 2012; Cramond et al., 2005), which could indicate that they measure distinct domain-specific forms of divergent thinking, or, in part, domain-specific abilities other than divergent thinking. As Coren (1995) pointed out, the Figural TTCT may tap into visuospatial or drawing abilities; left-handers could have an advantage in these abilities, rather than having an advantage in creativity, per se. Additionally, we speculate that a left-hander advantage in Figural Originality could be an artifact of scoring practices: Because some shapes might be easier to draw with the left hand, left-handers might tend to draw forms that are not more "original" but are different from what right-handers tend to draw. Raters who are right-handed, or are used to seeing drawings by right-handers, might then incorrectly label left-handers' drawings as more "original."

Overall, we do not find evidence that left-handers show increased divergent-thinking ability in laboratory tests. If anything, *right-handedness* may lead to an advantage on the AUT (and possibly on the RAT, on the basis of the point estimates). The largest included study, Zickert et al. (2018a), found that moderate right-handers (not strong right-handers) showed the highest scores, suggesting a potential effect of mixed handedness. However, moderate left-handers did not show any comparable advantage, scoring lower than both moderate and strong right-handers. There is some suggestive evidence that strong left-handedness may confer an advantage on the Figural Torrance Tests, but this effect, if reliable, might be better interpreted as a difference in visuospatial ability, or could reflect the mechanics of drawing, rather than indicating an advantage in creativity for left-handers.

Meta-analysis: Handedness and creative professions

If left-handers were more creative, they might be more likely to succeed in creative fields. Sometimes, great artists, from Leonardo DaVinci to Paul McCartney, are upheld as exemplars of left-handers' creative prowess. But are left-handers statistically overrepresented in creative professions? To address this question, we first conducted a meta-analysis on Art, Music, and Architecture because multiple researchers have claimed that left-handers are overrepresented in these three fields (as summarized in Lindell, 2011; Porac, 2016).

However, finding left-hander overrepresentation in these specific fields might be a result of statistical double dipping. Maybe left-handers happen to be overrepresented in one or two creative fields for idiosyncratic reasons, and initial research finding overrepresentation in those fields was imitated, at the expense of investigating other creative fields that might show no overrepresentation. To find out whether left-handers are overrepresented in creative professions, in general, we reproduced and extended the analysis of a well-powered study that assessed handedness across a wide range of professions (Goodman, 2014).

Meta-analysis procedure

We aimed to identify and compile all available data on the relative representation of left- versus right-handers, and strong- versus mixed-handers, in Art, Music, and Architecture.

Transparency and openness

We followed the MARS guidelines for meta-analytic reporting (Appelbaum et al., 2018), with one exception: We deviated from these guidelines insomuch as our selection strategy (described below) relied on manual review; we therefore did not include a flowchart illustrating study selection, and a single investigator

(O.M.) coded studies for inclusion. All meta-analytic data, analysis code, and research materials are available in the repository (https://osf.io/xhpjy). Data were analyzed using R (Version 4.0.0; R Core Team, 2023) and the R packages *meta* (Version 5.2–0; Balduzzi et al., 2019) and *metafor* (Version 3.4–0; Viechtbauer, 2010). This review project was not preregistered.

Inclusion criteria

1. **Professions.** The article must have reported the frequency of left- or mixed-handedness in Art, Music, or Architecture, or provided enough information to calculate such a frequency.
2. **Control group.** The article must have reported the frequency of left- or mixed-handedness in an appropriate control group of people from other fields, demographically similar to the group in the creative field and assessed using the same measure of handedness. If a study described the handedness of people in a range of fields, the control group was constructed as the union of all fields outside Art, Music, and Architecture.
3. **Handedness.** The article must have reported an estimate of the frequency of left- or mixed-handedness for the creative and control group, or reported enough information to calculate these frequencies, such that an odds ratio could be estimated. The article could report any measure of handedness that enabled coding of right- versus left-handedness, or strong- versus mixed-handedness.
4. **Populations.** Populations of students, professionals, or hobbyists were included.
5. **Year, language, and publication type**. Any study published after 1900 was considered for inclusion. Because of the language abilities of the authors, only studies available in English were included. Both peer-reviewed journal articles and publicly available theses and dissertations were included.

Selection strategy

Candidate studies were identified based on a manual review of the literature, including following citations to and from the seed studies, Lindell (2011); Preti & Vellante, 2007; Peterson and Lansky (1974); and Good et al. (1997); and Google Scholar and PsychInfo searches for "(artists OR art) AND (handedness OR left-handed OR 'left hand' OR inconsistent-handed OR inconsistent-hander)"; "(architects OR architecture) AND (handedness OR left-handed OR 'left hand' OR inconsistent-handed OR inconsistent-hander)"; and "(musicians OR music) AND (handedness OR left-handed OR 'left hand' OR inconsistent-handed OR inconsistent-hander)." Because these search terms resulted in an unwieldy amount of hits (e.g., [artists OR art] AND [handedness OR left-handed OR inconsistent-handed OR inconsistent-hander] yielded about 67,000 results), we did not pursue a systematic search strategy using Google Scholar; instead, we manually searched through the first few pages of results for each search term and reviewed citations in results identified as relevant. On the other extreme, the domain-specific database PsychInfo yielded a very small number of results (for the same search term, [artists OR art] AND [handedness OR left-handed OR inconsistent-handed OR inconsistent-hander], PsychInfo yielded only 33 hits). Accordingly, the sample of included studies may be biased toward studies that have been highly cited, or that have been cited by highly cited studies. This bias could in principle increase the chances of including estimates that confirm authors' hypotheses, which may be more likely to be cited. In principle, therefore, meta-analytic estimates derived from this search could overestimate the prevalence of left-handers in creative professions.

Data extraction

Effect-size calculation Included studies reported enough information to estimate the odds ratio between the proportion of left-handers (or mixed-handers) in a control group, and a group of artists, musicians, or architects. When a study provided enough information to do so, odds ratios between both right and left, and strong- and mixed-handers, were extracted. Confidence intervals around odds ratios for each study were estimated with the R package *PropCIs* (Version 0.3–0) using the score confidence interval method, which has good coverage for small sample sizes, as described in Agresti (2013; see also Agresti & Min, 2005). The formula used to calculate score CIs implemented in *PropCIs*'s "orscorecis()" function is based on Mee (1984).

Handedness group coding The same procedure was used to code binary handedness groups as in the divergent-thinking tasks meta-analysis.

Profession group and population type coding Extracted effects were coded as "Art" if they estimated representation of students with art-related majors such as Fine Arts, faculty of art departments, professional artists, or people who report art as a preferred hobby. Effects were coded as "Music" if they estimated representation of music students or faculty, and professional or hobbyist musicians (including instrumental musicians, singers, and composers). Effects were coded as "Architecture" if they estimated representation of students or faculty in architecture, or professional architects. Effects were extracted for multiple fields when studies provided enough information to do so. Each effect was also coded by its population, as "professionals," "students," "faculty," or "hobbyists." This "population" variable was included as a random effect in meta-analytic models.

Data analyses

Effect-size pooling Effect sizes were pooled using a one-stage unconditional mixed-effects logistic regression model, directly using the counts for each group in each study. This one-stage approach has several advantages over traditional two-stage approaches that estimate pooled odds ratios by combining each study's preestimated effect and standard error (e.g., the Mantel–Haenszel method; Mantel & Haenszel, 1959). A one-stage approach makes use of the individual-level data that can be recovered from frequency tables, and yields exact likelihood estimates, without assuming that studies' effect estimates are normally distributed, or that studies' standard errors are known when they are, in fact, estimated (Simmonds & Higgins, 2016; Stijnen et al., 2010). As such, a one-stage approach may produce more reliable estimates of pooled odds ratios and their confidence intervals than traditional two-stage approaches (Chang & Hoaglin, 2017; but see Bakbergenuly & Kulinskaya, 2018). Models were estimated for each creative field and each handedness comparison using the R package *lme4*'s "glmer()" function, and heterogeneity estimates were calculated with *meta*'s "metabin()" function. The variables population (e.g., students or professionals), study, and handedness measure (e.g., EHI, writing hand) were modeled as random effects.

Publication bias Publication bias was assessed by visually inspecting funnel plots (Fig. 7). These plots do not reveal any strong asymmetry that would indicate pervasive publication bias.

Meta-analytic results

Our search yielded 19 studies that met inclusion criteria, with 62 effect sizes. Extracted effects for each creative field, and pooled estimates for both right- versus left-handedness and strong- versus mixed-handedness (as well as study characteristics) are shown in Table 3. Below we discuss the results of the meta-analysis; we also present a qualitative review of the included studies and discuss relevant studies that could not be included in the meta-analysis.

Art

Meta-analytic estimates suggest overrepresentation of both left-handers ($OR = 1.31$, 95% CI [1.02, 1.68], $p = 0.03$) and mixed-handers ($OR = 1.84$, 95% CI [1.50, 2.25], $p < 0.001$) in Art. Of three studies comparing art students to controls with other undergraduate majors, one found an advantage for strong left-handers (Mebert & Michel, 1980), and two for non-right-handers (Coren & Porac, 1982; Mebert & Michel, 1980). While Peterson (1979) reported overrepresentation of left-handedness in students of visual art compared with sciences, their data yielded a null result comparing the frequency of left-handedness in art students to students with

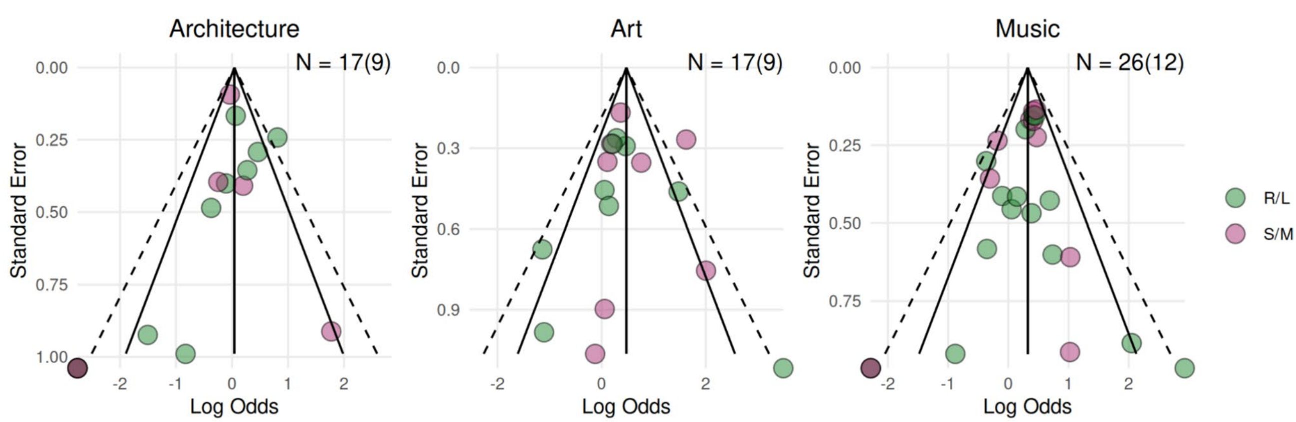

Fig. 7 Funnel plots to assess publication bias in creative professions meta-analyses. *Note*. Solid vertical lines indicate pooled effect estimates. Odds ratios are transformed to log odds so that symmetry can more easily be assessed visually; a positive logodds estimate corresponds to left- or mixed-hander overrepresentation. Solid and dotted angled lines show 95% and 99% confidence regions. "N" indicates the number of effects pooled, with the number of distinct studies in parentheses. Green dots show effects for right- versus left-handedness comparisons; purple dots show effects for strong- versus mixed-handedness comparisons. (Color figure online)

Table 3 Professions meta-analysis results and study characteristics

Prof	Comparison	Study [1]	Population	Creative group	Control group	Frequency of left-handedness (creative)	Frequency of left-handedness (control)	*OR* [2]	95% CI	*p*	Handedness groups [3]
Art	R/L	NLSY79	Professionals	Artistic occupations	Non-art/-music/-architecture occupations	2/43 (4.65%)	722/5468 (13.2%)	0.32	[0.09, 1.20]	0.15	R/L [4]
		Shettel-Neuber and O'Reilly (1983)	Faculty	Art	Law, psychology	1/30 (3.33%)	5/53 (9.43%)	0.33	[0.05, 2.31]	0.56	SR/SL (self-ID)
		Giotakos (2004)	Military	Art hobbies	Non-art hobbies	6/100 (6%)	25/439 (5.69%)	1.06	[0.43, 2.59]	0.99	SR/SL (extremes: cut at ±18/18)
		Cosenza and Mingoti (1993)	Students	Fine arts applicants	Non-art/-music/-architecture applicants	4/31 (12.9%)	1190/10422 (11.42%)	1.15	[0.42, 3.16]	0.99	SR/SL (cut at −10 and + 70/100)
		Coren and Porac (1982)	Students	Science/visual art	Lang/lit	28/225 (12.44%)	27/262 (10.31%)	1.24	[0.71, 2.16]	0.55	R/L (0-split)
		NLSY97	Professionals	Artistic occupations	Non-art/-music/-architecture occupations	19/78 (24.36%)	1184/6091 (19.44%)	1.33	[0.80, 2.24]	0.34	R/L [4]
		Peterson (1979)	Students	Design, arch., art	Non-art, music	18/147 (12.24%)	46/569 (8.08%)	1.59	[0.90, 2.81]	0.16	R/L (binary self-ID)
		Mebert and Michel (1980)	Students	Art	Non-art	21/75 (28%)	7/86 (8.14%)	4.39	[1.77, 10.82]	< 0.001	SR/SL (cut at ±50/100)
		Preti and Vellante (2007)	Professionals	Writers, painters	Non-writers/painters/musicians	2/42 (4.76%)	0/78 (0%)	Inf	[0.97, Inf]	0.23	SR/SL (extremes: cut at ±18/18)
Art	R/L	*Random effects model* $I^2 = 0.36$ [0.00, 0.71]						*1.31*	*[1.02, 1.68]*	*0.03*	
	S/M	Shettel-Neuber and O'Reilly (1983)	Faculty	Art	Law, psychology	1/31 (3.23%)	2/55 (3.64%)	0.88	[0.11, 7.17]	0.99	(SR + SL)/M (self-ID)
		NLSY79	Professionals	Artistic occupations	Non-art/-music/-architecture occupations	1/43 (2.33%)	120/5468 (2.19%)	1.06	[0.18, 6.16]	0.99	(SR + SL)/M [4]
		NLSY97	Professionals	Artistic occupations	Non-art/-music/-architecture occupations	9/78 (11.54%)	636/6091 (10.44%)	1.12	[0.56, 2.22]	0.90	(SR + SL)/M [4]

Table 3 (continued)

Prof	Comparison	Study [1]	Population	Creative group	Control group	Frequency of left-handedness (creative)	Frequency of left-handedness (control)	*OR* [2]	95% CI	*p*	Handedness groups [3]
		Cosenza and Mingoti (1993)	Students	Fine arts applicants	Non-art/-music/-architecture applicants	20/51 (39.22%)	5583/16005 (34.88%)	1.20	[0.69, 2.10]	0.62	(SR + SL)/M (cut at − 10 and + 70/100)
		Giotakos (2004)	Military	Art hobbies	Non-art hobbies	84/184 (45.65%)	256/695 (36.83%)	1.44	[1.04, 2.00]	0.04	(SR + SL)/M (extremes vs. betweens, cut at ± 18/18)
		Mebert and Michel (1980)	Students	Art	Non-art	28/103 (27.18%)	15/101 (14.85%)	2.14	[1.07, 4.28]	0.05	(SR + SL)/M (cut at ± 50/100))
		Coren and Porac (1982)	Students	Science/visual art	Lang/lit	69/225 (30.67%)	21/262 (8.02%)	5.08	[3.00, 8.58]	< 0.001	(SR + SL)/M (extremes vs. betweens, cut at ± 13/13)
		Preti and Vellante (2007)	Professionals	Writers, painters	Non-writers/-painters/-musicians	8/50 (16%)	2/80 (2.5%)	7.43	[1.68, 32.36]	0.01	(SR + SL)/M (extremes vs. betweens, cut at ± 18/18)
Art	S/M	*Random effects model* $I^2 = 0.71$ [0.40, 0.86]						*1.84*	*[1.50, 2.25]*	*< 0.001*	
Music	R/L	NLSY79	Professionals	Musicians and composers	Non-art/-music/-architecture occupations	0/12 (0%)	722/5468 (13.2%)	0.00	[0.00, 2.11]	0.36	R/L [4]
		NLSY97	Professionals	Musicians, singers and related workers	Non-art/-music/-architecture occupations	1/11 (9.09%)	1183/6090 (19.43%)	0.41	[0.07, 2.52]	0.63	SR/SL [4]
		Oldfield (1969)	Students/Faculty	Music students and faculty	Psychology undergrads	13/129 (10.08%)	157/1128 (13.92%)	0.69	[0.38, 1.25]	0.28	R/L (0-split)
		Byrne (1974)	Students	Instrumental musicians	General students	3/75 (4%)	38/678 (5.6%)	0.70	[0.22, 2.20]	0.75	SR/SL (cut at ± 50/100)
		Götestam (1990)	Students	Music (freshmen)	High school seniors	13/88 (14.77%)	14/87 (16.09%)	0.90	[0.40, 2.03]	0.97	(SR + MR) /(SL + ML) [5]
		Giotakos (2004)	Hobbyists	Art hobbies	Non-art hobbies	6/100 (6%)	25/439 (5.69%)	1.06	[0.43, 2.59]	0.99	SR/SL (extremes vs. betweens, cut at ± 18/18)
		Byrne (1974)	Students	Singers	General students	7/109 (6.42%)	38/678 (5.6%)	1.16	[0.51, 2.61]	0.91	SR/SL (cut at ± 50/100)

Table 3 (continued)

Prof	Comparison	Study [1]	Population	Creative group	Control group	Frequency of left-handedness (creative)	Frequency of left-handedness (control)	*OR* [2]	95% CI	*p*	Handedness groups [3]
		Aggleton et al. (1994)	Professionals	Composers	British adults	36/331 (10.88%)	129/1538 (8.39%)	1.33	[0.90, 1.97]	0.18	R/L (0-split)
		Fry (1990)	Students	Music theory/composition	Non-music	6/31 (19.35%)	47/335 (14.03%)	1.47	[0.59, 3.69]	0.59	R/L (0-split)
		Aggleton et al. (1994)	Professionals	Instrumental musicians	British adults	76/623 (12.2%)	129/1538 (8.39%)	1.52	[1.12, 2.05]	0.01	R/L (0-split)
		Aggleton et al. (1994)	Professionals	Choir members	British adults	73/584 (12.5%)	129/1538 (8.39%)	1.56	[1.15, 2.12]	0.01	R/L (0-split)
		Peterson (1979)	Students	Music	Non-art, music	7/47 (14.89%)	46/569 (8.08%)	1.99	[0.86, 4.61]	0.18	R/L (binary self-ID)
		Quinan (1922)	Professionals	Instrumental musicians	Machinists	8/100 (8%)	4/100 (4%)	2.09	[0.64, 6.76]	0.37	R/L (binary self-ID)
		Cosenza and Mingoti (1993)	Students	Music applicants	Non-art/-music/-architecture applicants	2/4 (50%)	1190/10422 (11.42%)	7.76	[1.37, 44.00]	0.10	SR/SL (cut at − 10 and + 70/100)
		Preti and Vellante (2007)	Professionals	Musicians	Non-writers/-painters/-musicians	3/28 (10.71%)	0/78 (0%)	Inf	[2.30, Inf]	0.02	SR/SL (extremes vs. betweens, cut at ± 18/18)
Music	R/L	*Random effects model* $I^2 = 0.02$ [0.00, 0.55]						*1.32*	*[1.14, 1.54]*	*< 0.001*	
	S/M	NLSY79	Professionals	Musicians and composers	Non-art/-music/-architecture occupations	0/12 (0%)	120/5468 (2.19%)	0.00	[0.00, 14.36]	1.00	(SR + SL)/M [4]
		NLSY97	Professionals	Musicians, singers and related workers	Non-art/-music/-architecture occupations	0/11 (0%)	635/6090 (10.43%)	0.00	[0.00, 3.00]	0.52	(SR + SL)/M [4]
		Götestam (1990)	Students	Music (freshmen)	High school seniors	65/88 (73.86%)	69/87 (79.31%)	0.74	[0.37, 1.48]	0.50	(SR + SL)/M [5]
		Byrne (1974)	Students	Singers	General students	25/134 (18.66%)	186/864 (21.53%)	0.84	[0.53, 1.33]	0.52	(SR + SL)/M (cut at ± 50/100)
		Giotakos (2004)	Hobbyists	Art hobbies	Non-art hobbies	84/184 (45.65%)	256/695 (36.83%)	1.44	[1.04, 2.00]	0.04	(SR + SL)/M (extremes vs. betweens, cut at ± 18/18)

Table 3 (continued)

Prof	Comparison	Study [1]	Population	Creative group	Control group	Frequency of left-handedness (creative)	Frequency of left-handedness (control)	*OR* [2]	95% CI	*p*	Handedness groups [3]
		Aggleton et al. (1994)	Professionals	Composers	British adults	52/331 (15.71%)	169/1538 (10.99%)	1.51	[1.08, 2.11]	0.02	(SR + SL) /(ML + MR) (cut at ± 60/100)
		Aggleton et al. (1994)	Professionals	Choir Members	British adults	92/584 (15.75%)	169/1538 (10.99%)	1.51	[1.15, 1.99]	0.00	(SR + SL) / (ML + MR) (cut at ± 60/100)
		Aggleton et al. (1994)	Professionals	Instrumental musicians	British adults	102/623 (16.37%)	169/1538 (10.99%)	1.59	[1.22, 2.07]	< 0.001	(SR + SL) / (ML + MR) (cut at ± 60/100)
		Byrne (1974)	Students	Instrumental musicians	General students	33/108 (30.56%)	186/864 (21.53%)	1.60	[1.03, 2.49]	0.05	(SR + SL)/M (cut at ± 50/100)
		Preti and Vellante (2007)	Professionals	Musicians	Non-creatives	2/30 (6.67%)	2/80 (2.5%)	2.79	[0.46, 16.73]	0.64	(SR + SL)/M (extremes vs. betweens, cut at ± 18/18)
		Cosenza and Mingoti (1993)	Students	Music applicants	Non-art/-music/-architecture applicants	6/10 (60%)	5583/16005 (34.88%)	2.80	[0.85, 9.24]	0.18	(SR + SL)/M (cut at − 10 and + 70/100)
Music	S/M	*Random effects model* $I^2 = 0.10$ [0.00, 0.50]						*1.42*	*[1.25, 1.61]*	*< 0.001*	
Architecture	R/L	NLSY79	Professionals	Architects, except naval	Non-art/-music/-architecture occupations	0/9 (0%)	722/5468 (13.2%)	0.00	[0.00, 2.81]	0.50	R/L [4]
		NLSY97	Professionals	Architects, except naval	Non-art/-music/-architecture occupations	0/4 (0%)	1183/6090 (19.43%)	0.00	[0.00, 3.99]	0.73	SR/SL [4]
		Wood and Aggleton (1991)	Students	Architecture students (W)	General students (W)	1/27 (3.7%)	22/149 (14.77%)	0.22	[0.04, 1.37]	0.21	R/L (0-split)
		Shettel-Neuber and O'Reilly (1983)	Faculty	Architecture	Law, psychology	1/23 (4.35%)	5/53 (9.43%)	0.44	[0.06, 3.10]	0.77	SR/SL (self-ID)
		Götestam (1990)	Students	Architecture (freshmen)	High school seniors	7/60 (11.67%)	14/87 (16.09%)	0.69	[0.27, 1.79]	0.61	(SR + MR) / (SL + ML) [5]

Table 3 (continued)

Prof	Comparison	Study [1]	Population	Creative group	Control group	Frequency of left-handedness (creative)	Frequency of left-handedness (control)	*OR* [2]	95% CI	*p*	Handedness groups [3]
		Wood and Aggleton (1991)	Students	Architecture students (M)	General students (M)	9/78 (11.54%)	28/221 (12.67%)	0.90	[0.41, 1.97]	0.95	R/L (0-split)
		Cosenza and Mingoti (1993)	Students	Architecture applicants	Non-art/-music/-architecture applicants	42/347 (12.1%)	1190/10422 (11.42%)	1.07	[0.77, 1.48]	0.76	SR/SL (cut at – 10 and + 70/100)
		Fry (1990)	Students	Architecture	Non-architecture	12/69 (17.39%)	41/297 (13.8%)	1.31	[0.66, 2.64]	0.57	R/L (0-split)
		Peterson (1979)	Students	Design, arch., art	Non-art, music	18/147 (12.24%)	46/569 (8.08%)	1.59	[0.90, 2.81]	0.16	R/L (binary self-ID)
		Schachter and Ransil (1996)	Professionals	Architects	Non-architects	26/141 (18.44%)	92/1007 (9.14%)	2.25	[1.40, 3.61]	0.00	SR/SL (self-ID)
Architecture	R/L	*Random effects model*						*1.15*	*[0.93, 1.42]*	*0.19*	
		$I^2 = 0.31$ [0.00, 0.67]									
	S/M	Shettel-Neuber and O'Reilly (1983)	Faculty	Architecture	Law, psychology	0/23 (0%)	2/55 (3.64%)	0.00	[0.00, 4.74]	0.89	(SR + SL)/M
		NLSY79	Professionals	Architects, except naval	Non-art/-music/-architecture occupations	0/9 (0%)	120/5468 (2.19%)	0.00	[0.00, 19.16]	1.00	(SR + SL)/M [4]
		NLSY97	Professionals	Architects, except naval	Non-art/-music/-architecture occupations	0/4 (0%)	635/6090 (10.43%)	0.00	[0.00, 8.27]	1.00	(SR + SL)/M [4]
		Götestam (1990)	Students	Architecture (freshmen)	High school seniors	45/60 (75%)	69/87 (79.31%)	0.78	[0.36, 1.70]	0.68	(SR + SL)/M [5]
		Cosenza and Mingoti (1993)	Students	Architecture applicants	Non-art/music/architecture applicants	179/526 (34.03%)	5583/16005 (34.88%)	0.96	[0.80, 1.16]	0.72	(SR + SL)/M (cut at –10 and + 70/100)
		Schachter and Ransil (1996)	Professionals	Architects	Non-architects	7/148 (4.73%)	41/1048 (3.91%)	1.22	[0.55, 2.72]	0.80	(SR + SL)/M (self-ID)
		Wood and Aggleton (1991)	Students	Architecture students (W)	General students (W)	2/27 (7.41%)	2/149 (1.34%)	5.88	[0.99, 35.16]	0.21	(SR + SL)/M (self-ID)
	S/M	*Random effects model*						*0.97*	*[0.81, 1.15]*	*0.70*	
		$I^2 = 0.00$ [0.00, 0.71]									

Table 3 (continued)

[1] "NLSY79" and "NLSY97" are the two National Longitudinal Survey of Youth datasets analyzed in Goodman (2014)

[2] Odds ratios (OR) greater than 1 indicate that leftor mixed-handers are overrepresented in the creative group; ORs less than 1 mean that right- or strong-handers are overrepresented. "95% CI" shows the 95% confidence bounds on the estimated odds ratio "OR." Italics indicate pooled estimates from a generalized linear model with study, population, handedness binning, and effect size number as random effects

[3] "R/L": authors reported two handedness bins, without a classification for mixed handedness. "(SR + SL) / M"): Authors reported bins of strong-handers (strong left- and right-handers pooled together) and mixed-handers, or separately reported bins of strong left- and right-handers, who could be pooled together and compared with mixedhanders. "(SR + SL) / (MR + ML)": authors reported four handedness bins, which were pooled as strong left- and right-handers, compared with mixed right- and mixed left-handers. When available, the numerical cutoffs used to bin handedness groups are described (e.g., "S/M (cut at ± 75/100)" means that participants with a score greater than 75, or less than − 75, in a 100-point hand-preferences scale, were classified as strong-handers, and those in between were classified as mixed-handers. "0 split" = Participants with handedness inventory scores less than zero are considered left-handed; those with scores greater than zero are considered right-handed. "median split" = Leftand right-handedness were binned on either side of the sample median. "Extremes" or "extremes vs. betweens" indicates that authors classified participants as strongly right- or left-handed, if they showed the maximum or minimum score on a handedness-preference questionnaire, and classified participants with intermediate scores as mixed handed.)

[4] Goodman (2014) coded handedness in the NLSY79 and NLSY97 datasets as follows: "Each of the five datasets asks somewhat different questions regarding handedness. Some ask adults; some ask mothers; some use data from interviewers who observed children. For each question asked about handedness, I assign a value of one to answers that clearly favor the left hand (such as "always left" or "usually left") and a value of zero to answers that clearly favor the right hand. I assign a value of one-half to answers indicating mixed-handedness or a lack of hand preference. I compute for each individual in each year the mean response to handedness questions and also compute the mean of these values across all years. Most individuals can be easily categorized as right- or left-handed. To construct a binary measure of left-handedness, I round this continuous measure to the nearest integer

[5] Götestam (1990) calculated handedness from a fouritem (writing, throwing a ball, threading a needle, and kicking a ball), 3-point hand-preference scale, yielding scores from 4 to 12. They defined four handedness categories: "left" (left hand on all items), "left mixed" (always write with left, but do one or more other things with the right hand), "right mixed," and "right." Here, two-0handedness comparisons are used: R/L (writing hand = left + left mixed vs. right + right mixed), and S/M (right + left / mixed right + mixed left)

all other majors. Additionally, Cosenza and Mignoti (1993) report no significant difference in the frequency of left-handedness between applicants to art programs compared with applicants to other majors.

Preti and Vellante (2007) found that non-right-handers were overrepresented among both painters and professional writers compared with controls in other professions. Finally, in a group of young Israeli army conscripts, Giotakos (2004) found that mixed-handers were overrepresented among those who preferred hobbies fitting the description "Art: playing music, drawing, handicraft," compared with other hobbies. One study of university faculty members found a null result in comparing the frequency of left-handedness in arts department faculty to that in law (Shettel-Neuber & O'Reilly, 1983). Overall, the majority of studies suggest that left-handers and mixed-handers disproportionately pursue art.

Two further studies were excluded from the meta-analysis because they did not compare left-handed artists to an appropriate control group. One art-historical study found that only 2.8% of 500 historical painters were left-handed (L'Anthony, 1995), when handedness was inferred from portraits and the direction in which artists drew shading lines (right-handers tend to draw shading lines from the bottom left towards the upper right). This estimate is lower than expected under the prediction that left-handedness is overrepresented among great artists—at least, it is lower than a conservative estimate of 9.3% as the rate of left-handedness in the current population (Papadatou-Pastou et al., 2020). Additionally, Røsvoll et al. (2023) found that people who posted visual art on Instagram showed a rate of left-handedness of 42/468 (8.97%), similar to (but not greater than) the rate of left-handedness in the general population. Neither of these studies supports the claim that left-handers are overrepresented in Art, but their methods limit the inferences they can support.

Considering only studies with appropriate control groups, there appears to be support for the overrepresentation of left-handers and mixed-handers in Art, across different levels of expertise (i.e., student, faculty, professional, hobbyist) and different media (e.g., writing, drawing, painting, handicraft).

Music

Meta-analytic estimates suggest that left-handers ($OR = 1.32$, 95% CI [1.14, 1.54], $p < 0.001$) and mixed-handers ($OR = 1.42$, 95% CI [1.25, 1.61], $p < 0.001$) are overrepresented in music. Two studies of professional musicians have found left- or mixed-hander overrepresentation (Aggleton et al., 1994; Preti & Vellante, 2007), and one yielded a null result (Quinan, 1922). One study of hobbyists supported a link between mixed-handedness and music (Giotakos, 2004). Jäncke et al. (1997) found that right-handed musicians had lower hand-skill asymmetry than a control group of non-musician right-handers; thus, even "right-handed" musicians may be more mixed-handed than non-musicians. (This study could not be included in meta-analysis because it did not report a comparison group of left-handers).

Contrary to these four studies linking left- and mixed-handedness with music, several of the studies included in the meta-analysis did not find any overrepresentation of left- and mixed-handers among music students (Fry, 1990; Götestam, 1990; Oldfield, 1969). Byrne (1974) found that non-right-handers were overrepresented among instrumental music students, but not vocal music students, and not in the combined sample of instrumental and vocal students. Despite these null results, the meta-analysis shows statistical overrepresentation of left- and mixed-handers among musicians, both professionals and hobbyists.

A further study was not included in the meta-analysis because it did not compare left-handed musicians to a non-musician control group (Christman, 1993). This study by Christman (1993) is potentially of interest, however, because it suggests a potential explanation for the relationship between handedness and music found in our meta-analysis. Christman (1993) compared handedness in musicians who play "bimanually integrated" instruments such as strings and woodwinds, versus "bimanually independent" instruments such as the piano. The author found that while direction of handedness did not differ significantly between these two groups, those who played bimanually integrated instruments showed lower hand-skill asymmetry. Accordingly, the overrepresentation of mixed-handers among musicians could be due, in part, to the fact that playing certain instruments requires the coordinated use of both hands; since left-handers tend to be more mixed-handed on average than right-handers, this account could also potentially help to explain the overrepresentation of left-handers in music.

Architecture

Meta-analytic estimates do not suggest left-hander ($OR = 1.18$, 95% CI [0.98, 1.40], $p = 0.07$) or mixed-hander ($OR = 0.97$, 95% CI [0.81, 1.15], $p = 0.70$) overrepresentation in architecture. Only one study found significant left-hander overrepresentation, comparing professional architects to professionals in other fields (Schachter & Ransil, 1996). By contrast, six studies with seven effect sizes did not find any statistical overrepresentation of left-handers, within architecture students (Cosenza & Mingoti, 1993; Fry, 1990; Götestam, 1990; Peterson, 1979; Wood & Aggleton, 1991) or architecture faculty (Shettel-Neuber & O'Reilly, 1983). Additionally, five studies found no statistical overrepresentation of mixed-handers (Cosenza & Mingoti, 1993; Götestam, 1990; Schachter & Ransil, 1996; Shettel-Neuber & O'Reilly, 1983; Wood & Aggleton, 1991).

Several studies were not included in the meta-analysis because they did not compare left-handed architects with an appropriate control group. Three of these studies concluded that left- or mixed-handers were overrepresented in architecture: Peterson and Lansky (1974) reported that a high percentage of architecture students (16.3%) were left- or mixed-handed. Peterson and Lansky also reported that a high proportion of architecture-school faculty members (29.4%) were non-right-handed: this proportion held after 50% faculty turnover (Lansky & Peterson, 1985). Peterson and Lansky (1977) compared the proportion of left-handers in a graduating versus entering class of architecture students. The authors argued that because the proportion of left-handers was greater in the graduating class than in the entering class, left-handers may be more successful in architecture. The lack of non-architecture control groups in these three studies makes interpretation difficult, however, and meta-analysis of studies with appropriate control groups shows no evidence that left-handers are overrepresented among architecture students or faculty. Together, the evidence does not support the often-cited claim that left- or mixed-handers are more likely to pursue, or to succeed in, architecture.

Creative professions beyond art, music, and architecture

So far, we have analyzed the evidence for a left-hander advantage in art, architecture, and music, fields which have been repeatedly referenced as sites of left-hander creativity. Although we found no evidence that left- or mixed-handers are overrepresented in architecture, we found that left- and mixed-handers may indeed be overrepresented in art and music. However, these three professions were not sampled in an unbiased manner from the set of all professions, or even all "creative professions." Across the full range of possible fields and occupations, do left-handers tend to pursue or succeed in jobs that require more creativity?

One large analysis of a wide range of professions suggests that left-handers may be *underrepresented* in creative professions. Combining two longitudinal datasets reporting individuals' occupations and handedness, totaling 11,715 participants in 771 professions, Goodman (2014) evaluated whether left-handers' occupations, on average, require more creative ability. Using an index from the US Department of Labor's Occupational Information Network (O*NET), Goodman coded each occupation by the extent to which it required manual and cognitive skills, including a creativity score combining "Originality" and "inductive reasoning." The O*NET ratings are generated by a team of occupational analysts who follow standardized procedures to rate the abilities needed for each indexed occupation based on structured descriptions from workers in each occupation (Donsbach et al., 2003). While these ratings have not been compared with psychological measures related to creative thinking, they represent an unbiased rating of the creativity of a range of professions, in the specific sense that they are not subject to the selection bias that might have emerged in the psychology literature. On O*NET's rating scheme, the professions highest in Originality include "Physicists," "Mathematicians," and "Fine Artists, Including Painters, Sculptors, and Illustrators." Goodman (2014) found that left-handers tended to have occupations that required *less* originality and inductive reasoning than did right-handers. Goodman did not report the effect size of this difference, but made his analysis and data publicly available. We reproduced his analysis of the group difference in mean occupation creativity score between right and left-handers, confirming that left-handers' occupations required slightly less creativity ($D = 0.082$, 95% CI [0.016, 0.148], $p = 0.015$; see Fig. 8). Additionally, we extended Goodman's analyses to test whether the level of creativity required by an occupation correlated with the proportion of left-handers who pursue it, across all occupations. We found that, as occupation creativity score increases, the percentage of left-handers decreases, $r(771) = -0.08$, $p = 0.02$; see Fig. 9 for a visualization of the proportion of left-handers in each quartile, by occupation creativity score). Indeed, left-handers were *underrepresented* in the quartile of people with the most highly creative

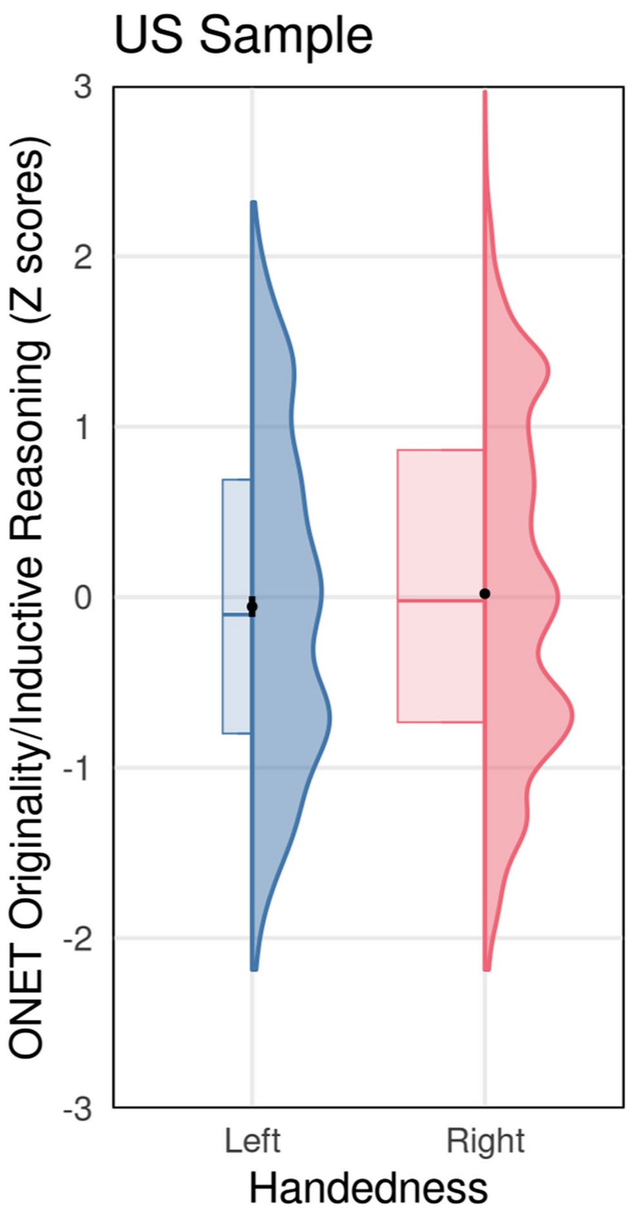

Fig. 8 Data from Goodman (2014): Mean occupation creativity for right versus left-handers. *Note*. Visualization of the group difference in mean occupation creativity score between left- and right-handers, an analysis reproduced from Goodman (2014). The data are Goodman's "US sample," combining the NLSY79 and NLSY97 datasets ($n = 11{,}715$), with Goodman's occupation coding and originality/inductive reasoning scores derived from O*NET. Dots and error-range lines show means and 95% CI; box plots show medians and interquartile range; and violins show smoothed kernel density estimates. Across all occupations sampled ($n = 771$), left-handers' occupations require slightly less originality/inductive reasoning than right-handers' ($D = 0.082$, 95% CI [0.016, 0.148], $p = 0.015$)

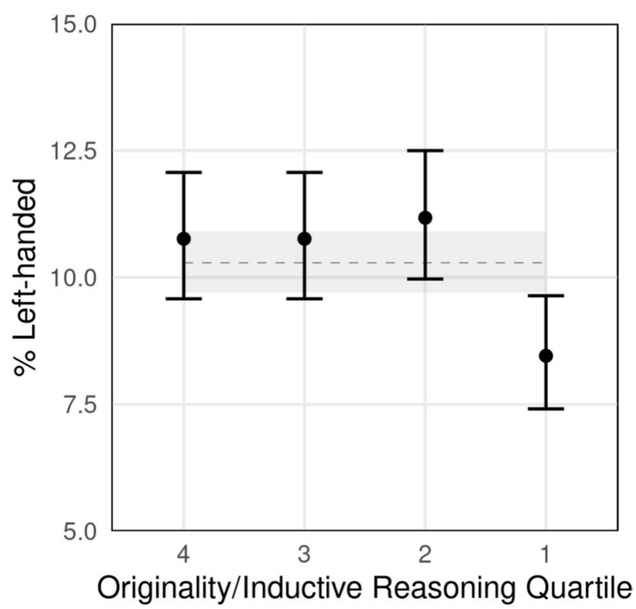

Fig. 9 Data from Goodman (2014): Proportion of left-handers by occupation creativity quartile. *Note*. Proportion of left-handers in each quartile of occupation creativity ratings, derived from Goodman's (2014) "US sample" ($n = 11{,}715$) with occupation creativity scores combining O*NET's originality and inductive reasoning ratings. Left-handers are underrepresented in the most highly creative quartile, Quartile 1. Dots represent the percentage of left-handers in each quartile, with 95% CIs calculated using Wilson's (1927) score method. The dotted line shows the proportion of left-handers in the whole sample, and the shaded area shows the 95% CI around this proportion

occupations, $\chi^2(1) = 11.38$, $p = 0.001$. These analyses suggest that, across a wide range of possible occupations, left-handers do not tend to choose or succeed in occupations that require more creativity. Rather, right-handers were overrepresented in professions requiring the most creativity.

Left-handers may have advantages in some professions. For example, left-handers may be overrepresented in interactive sports such as tennis (Loffing et al., 2012), baseball (Chu et al., 2016), and combat sports (Richardson & Gilman, 2019), in which having a less common stance might give a competitive advantage (Raymond et al., 1996). Additionally, Goodman (2014) found that left-handers were more likely to have occupations that require "manual labor." We find no evidence, however, that left-handers have an advantage in occupations that require creativity. On the contrary, when a wide range of professions is considered, left-handers tend to be found most frequently in fields that require *less* creative ability (Goodman, 2014). As such, the findings of left-hander overrepresentation in art and music should not be interpreted as evidence for overrepresentation in creative professions, per se. If anything, it appears that right-handers have an advantage in professions that rely on creative thinking.

Self-reported creativity

Even though left-handedness does not seem to be linked to better divergent thinking or more success in creative professions, left-handers reliably describe themselves as being more creative than right-handers do. For example, Zickert et al. (2018a) found that non-right-handers rated themselves most highly in response to the questions "How artistically creative are you?" and "How creative are you in problem solving?" reported on a self-assessment scale of – 100 to 100. Van der Feen et al. (2020) reported that, in the same sample used by Zickert et al. (2018a), degree of left-hand skill correlated with self-assessments of artistic creativity (however, the direction of this correlation was reversed for creative problem solving, and higher hand-skill asymmetry correlated with increased self-reported time spent on creative activities). Badzakova-Trajkov et al. (2011) found that reported level of "creative achievement" correlated with degree of left-handedness, and Law and Geng (2019) found that left-handers assessed themselves as being more innovative than did right-handers (as measured by items such as "coming up with new ideas" and "questioning new things"). Singg and Martin (2015) found that left-handers rated themselves more highly on the Artistic Abilities subscale of the Self-Directed Search Form R (Holland et al., 1994). Together, these results suggest that regardless of whether left-handedness confers an advantage to creative thinking ability, left-handers tend to view themselves as especially creative.

Discussion

We find that, contrary to popular belief, left-handers are not more creative than right-handers. On the basis of laboratory studies testing more than 10,000 right and left-handers, we conclude that left-handers do not show an advantage in divergent thinking. Overall, our meta-analysis suggests that, if anything, right-handers may have a slight advantage in divergent thinking, as measured by the AUT (Christensen et al., 1960). Left-handers show a slight advantage on the figural, but not verbal, Torrance Tests (Torrance & Ball, 1984), but this advantage may be due to differences in visuospatial ability, or an artifact of some figures being easier to draw with the left hand. Furthermore, while our meta-analysis suggests that left-handers may be overrepresented in Art and Music, this overrepresentation is likely not due to a left-hander advantage in creativity. On the contrary, a large, real-world survey of profession choice suggests that left-handers are *underrepresented* in the most highly creative professions (Goodman, 2014).

Implications for theories of creativity and the brain

Both the right hemisphere and interhemispheric integration theories could motivate the prediction that left- or mixed-handers might show higher creativity than right-handers, if systematic patterns of hand use lead to relevant changes in brain areas important for coarse semantic coding, or interhemispheric communication, respectively (see Table 1). If handedness did influence creativity, these theories could offer potential mechanisms for why. However, the lack of evidence that left- or mixed-handers are more creative than right-handers does not directly challenge either theory of creativity in the brain, as the prediction that left- or mixed-handers should be more creative is not a necessary consequence of either theory. Instead, the pattern of results disconfirms the hypothesis we introduced here: that left- or mixed-handers may be more creative because their systematic patterns of hand use lead to systematic patterns of brain activity that should increase creativity, under either theory of creativity in the brain.

Why do people believe that left-handers are more creative?

Even though left-handers are not better at creative thinking, many people believe that left-handers are more creative (e.g., Grimshaw & Wilson, 2013). Why do people hold this (false) belief? Here, we propose a few speculative answers.

First, people might believe that left-handers have personality traits that promote creativity. Indeed, there is some evidence to support this belief. Christman (2014) found that mixed-handers showed higher sensation-seeking, lower authoritarianism, and lower sense of disgust than consistent handers. These traits might plausibly be linked to a preference for fields such as music and art, which, at least stereotypically, call for nonconformity. (Although Christman, 2014, did not find a significant difference for right vs. left-handers, defined as those having positive or negative scores on the EHI, the strong-hander groups consisted almost entirely of right-handers; therefore, this result is equally consistent with either a difference in strength, or in direction, of laterality.) Consistent with this account, Christman (2013) found that mixed-handers were more likely to prefer unpopular genres of music, compared with strong right-handers. Bryson et al. (2009) found that degree of left-handedness correlated positively with Intellectual Openness, which has been found to correlate with divergent-thinking ability (McCrae, 1987). However, in a sample of over 600 young adults, Grimshaw and Wilson (2013) found that both right and left-handers endorsed the belief that left-handers are more introverted and more open to experience; contrary to this belief, however, right- and left-handers did not differ significantly in openness. Killgore et al. (1999) also found no significant difference in openness between left- and right-handers. Overall, left-handers do not tend to have more creativity-linked personality traits, but people believe that they do. This stereotype may contribute to the false belief that left-handers are better at creative thinking.

Second, people might believe that left-handers are more creative because of the popular belief that creative geniuses are "tortured artists" (Schlesinger, 2009), coupled with the belief, seeded in truth, that left-handers are more likely to experience mental health problems. A range of large studies and meta-analyses suggest that mixed-handers have an increased prevalence of mood disorders, including externalizing problems (Odintsova et al., 2023), depression (Mundorf et al., 2024; but see Packheiser et al., 2021), schizophrenia (Dragovic & Hammond, 2005; Hirnstein et al., 2014; Mundorf et al., 2024; Somers et al., 2009; Sommer et al., 2001), and non-specific psychopathology (Mundorf et al., 2024). Some studies have found left-handers to be at higher risk for depression (Denny, 2009) and schizophrenia (Dragovic & Hammond, 2005) as well, but the evidence is stronger for mixed-handers: well-powered studies equipped to distinguish between left- and mixed-handedness have found greater prevalence of mood disorders among mixed-handers, but not left-handers (Hirnstein et al., 2014; Odintsova et al., 2023; Somers et al., 2009; see also Packheiser et al., 2021). In popular belief, however, both left- and mixed-handers may be seen as at greater risk of psychopathology, aligning with cultural beliefs that non-right-handedness itself is pathological (Kushner, 2017).

Some researchers have argued that schizophrenia and other mood disorders could, in principle, lead to increased creative output because they can impede prefrontal regulation (Ramey & Chrysikou, 2014), or because the propensity for delusional thinking might facilitate the ability to generate ideas that conflict with common sense (Kyaga et al., 2011). A number of biographical and observational studies have reported that creative artists tend to have higher rates of mental illness (Andreasen, 1987; Jamison, 1989; Ludwig, 1998). However, this putative evidence that mental illness is more common in great creative artists has relied on small samples and biographical data, and the process of assessing mental health symptoms based on historical information is ripe for confirmation bias (Schlesinger, 2009). One series of studies has tested for a systematic association between psychopathology and creativity by making use of Swedish census data recording mental health diagnoses and occupations. In a sample of more than 300,000 people with mental disorders, Kyaga et al. (2011) found that those with bipolar disorder were overrepresented in creative professions, and that those with schizophrenia were overrepresented in artistic, but not scientific creative professions. In a second study with a larger sample of more than 1.2 million, Kyaga et al. (2013) confirmed that people with bipolar disorder were overrepresented in creative professions, but found that people with schizophrenia were *underrepresented* (as were groups with all other psychopathologies in the dataset: unipolar depression, anxiety disorder, autism, ADHD, and substance abuse disorders). Because left-handers have been found to have a higher prevalence of schizophrenia, but not bipolar disorder (Mundorf et al., 2023, 2024), there is no evidence that left-handers show the particular forms of psychopathology that may be associated with creativity. However, in popular belief, the trope of the "tortured artist" may lead people to view creative genius as linked to general psychopathology (see Schlesinger, 2009, for a review). Combined with the popular belief that left-handers have generally higher psychopathology, the popular version of the "tortured artist idea" could lead people to mistakenly think that left-handers should be more creative.

Whatever the reason for the popular belief in left-handers' creativity, we find that this belief is not supported by the available evidence.

Limitations

Our meta-analysis of divergent-thinking tasks included a relatively small number of studies, with the largest pool including five effect sizes. Because random-effect meta-analyses with fewer than five studies may not offer substantially higher power than the included studies, the effect estimates from smaller pools should be interpreted cautiously (Jackson & Turner, 2017, estimated that random effects meta-analyses with four studies have a roughly 70% chance of having greater power than each included study;

three studies, around 65%). The estimates from smaller pools of studies have a relatively higher risk of Type II error than meta-analytic estimates drawn from larger pools. Accordingly, the null results from smaller pools should not be taken on their own to falsify claims that left- or mixed-handers show greater divergent thinking than right-handers—these estimates should only be interpreted in light of the overall pattern of results across studies and pools and contextualized by qualitative review. Additionally, when the number of studies is small, the risk of publication bias cannot be quantified reliably; so, strong conclusions cannot be drawn about whether there is a high risk of publication bias in the sample of included studies. The risk of biased estimates from publication bias can be mitigated by including gray literature, as was done in the present analyses. Fortunately, if publication bias were high, this would increase the risk of Type I error (i.e., false positive results showing greater creativity in left- or mixed-handers), rather than inflating the risk of finding null results, as was the overall pattern in our effect estimates. Despite the limitations of meta-analytic estimates from pools with relatively few studies, we included estimates from such pools because (1) the number of studies that would meet inclusion criteria was not known in advance, and omitting small pools could be a source of selection bias, and (2) the effect estimates from even small pools of studies (any number of effect sizes greater than two) provide some information about the underlying distribution of effect sizes, above and beyond the effects of individual studies (Jackson & Turner, 2017). While the effect estimates from the smaller pools could be misleading if not interpreted with caution, reporting the meta-analytic estimates from all pools of studies that meet inclusion criteria provides quantitative information that can serve as a useful supplement to our qualitative review.

While the pools of studies in the creative professions meta-analysis were relatively larger (with the number of effect estimates ranging from seven to 15), our seed-based selection strategy may have been biased toward highly cited studies, resulting in an increased risk of false positives. Accordingly, the estimates of left- and mixed-hander's overrepresentation in art and music should be interpreted with caution. Further, the selection of "creative professions" that have been claimed to be associated with handedness in the literature represents a form of "double dipping," carrying a substantial risk of false positives with respect to the claim that left-handers are more likely to be found in creative professions, in general. We include a meta-analysis of the biased sample of "Creative professions," Art, Music, and Architecture, to characterize the state of the literature and the status of the specific evidential claims that have been taken to support the idea that left-handers are more creative. As we argue, finding left- or mixed-hander overrepresentation in these fields would provide, at best, weak evidence for this claim. For this reason, qualitative review, as well as our review and reanalysis of the representation of left-handers in a large sample of professions that are not subject to this selection bias, are critical for assessing the claim that left-handers may be overrepresented in creative professions, in general.

Our analyses did not include a formal analysis of risk of bias, such as the Newcastle–Ottawa Scale (NOS; Wells et al., n.d.) or RoB (Sterne et al., 2019). Such formal analyses are critical in the context of interventional or epidemiological studies where participant inclusion is based on complex criteria, or systematically different features of participants in case and control groups may confound effect estimates. Although any meta-analysis could benefit from use of a standardized quality assessment, the definition of hand preference in our included studies was relatively straightforward: The specific definitions used in each study are reported in Tables 2 and 3. The qualitative pattern of results suggests no concerning systematic differences between studies using different definitions of hand preference. In principle, population differences between studies could influence the relation between handedness and our outcome measures (divergent thinking and pursuit of creative professions). For example, in principle handedness stigma could decrease left-handers' pursuit of creative professions for fear of nonconformity, or increase it, if left-handers who feel othered become more likely to pursue unconventional vocations. In each included study, the groups being directly compared (i.e., right- vs. left-handers or creative vs. non-creative professionals) were drawn from the same populations, working against risk of bias from population differences. Handedness stigma can vary across cultures, geography, and time (Kushner, 2017; McManus, 2009; Papadatou-Pastou et al., 2020), and the amount of stigma in the population of each included sample could not be coded in any straightforward way. Almost all studies were drawn from North American samples collected after the mid-twentieth century, however, and therefore levels of social stigma should be comparable across study populations.

Conclusions

Two leading theories of creativity in the brain provide potential mechanisms by which left-handers (or mixed-handers) could develop an advantage in creative thinking over right-handers. According to our review and meta-analyses, however, left-handers show no reliable advantage in laboratory tests of divergent thinking. On the contrary, *right-handers* may show a small advantage as measured by the AUT. In the TTCT, left-handers may perform better than others on the Figural subtest, but no such difference has been found in the Verbal subtest. Arguably, the effect of handedness on the Figural subtest may not be due to a difference in divergent thinking but rather to a difference in visuospatial ability, or in the mechanics of drawing. Together, the results of three of the most commonly used tests of creative thinking do not support any advantage in creativity for left- or mixed-handers: the evidence that has most often been cited as supporting the claim that left-handers are especially creative does not stand on solid ground.

Although left-handers may be overrepresented in Art and Music, they are not overrepresented in creative professions, in general. On the contrary, when a broad sample of professions are considered, it appears that, if anything, *right-hander*s are more likely to succeed in jobs that require creativity. According to studies of self-reported creativity, and of personality stereotypes, right and left-handers, alike, *believe* that left-handers are more creative than right-handers. However, our analyses suggest that this belief is a "conventional absurdity"—an idea that is widely accepted even though there is no clear evidence that it is true.

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Data availability Meta-analytic data are available in the repository: https://osf.io/xhpjy

Code availability Analysis scripts are available in the repository: https://osf.io/xhpjy

Declarations

Ethics approval Not applicable.

Consent to participate Not applicable.

Consent for publication Not applicable.

Conflicts of interest The authors have no relevant competing interests to disclose.

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References marked with an asterisk ("*") indicate studies included in the meta-analysis of handedness and divergent thinking. References marked with a double asterisk ("**") indicate studies included in the meta-analysis of handedness and creative professions.

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