E-TAN platform and E-Baking Tray Task potentialities: new ways to solve old problems

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Abstract. Spatial abilities allow humans to perceive and act in the world around them. Combining technology with a wide used neuropsychological test, the E-Baking Tray Task have proved to be very versatile and useful. Here we examine its properties and potentialities, trying to propose new challenges in visuospatial cognition. Firstly, we address to actual algorithms of data analysis and propose new ones. Then we propose several new variables that could be inspected related to spatial exploration measured with this new device: verticality, stress, emotions, explored areas in peri-personal space and so on.

Keywords: Baking Tray Task, Visuospatial Abilities, E-TAN, E-BTT.

1 Introduction

Humans tend to perceive the world around them as made up of affordances [1] – that is, opportunities for action. Thus, it is clear that for humans is essential to be able to perceive the world around them – mostly with vision – and to navigate through it. Combining technology with the natural human capability to explore the world can thus enhance our knowledge of cognition and human brain.

Visuospatial abilities are an important aspect of cognitive functioning. From an evolutionary standpoint, its role in environmental adaptation was fundamental for our ancestors. One evidence of the central part they play in everyday life comes from neuropsychology: neglect (technically called unilateral eminegligence) is a severe syndrome in which patients are not able to detect, perceive and explore the part of the space that is controlateral to the brain lesion, usually of vascular origin [2].

These patients direct their attention only to the right side of the space – and often of their body too – while the left side is neglected. That is, they eat only from the right side of the plate, they dress and they comb only their right part, they only look towards right-sided stimuli, like their spatial attention is magnetically attracted only by them. During clinical assessment, they perform as though there was no left side of the space: they draw only the right half of a picture, they cancel only stimuli on the right side and so on. They are usually unaware of their deficits – something called anosognosia – which can make the recovery more problematic.

2 From analogic to digital: neglect assessment tools

2.1 Baking Tray Task

Many tests have been developed to assess neglect. We will focus on one of them: the Baking Tray Task (BTT). It was initially developed by Tham and Tegnér [3] and proved to be “quick and yet sensitive test, suitable for screening purposes and longitudinal studies” (p. 19). The aim of the two researchers was to suggest a valid alternative to pencil-and-paper classic tasks for neglect clinical assessment which, on one hand are widely used and reliable, but on the other have ecological limitation [4]. Indeed, chronic neglect patients can show signs of remission from their spatial deficits to clinical tests while still having severe problems in real life situation, as reported by their caregivers. This can be explained with compensatory strategies that can mask difficulties: Takamura and collegues [5] found out that patients who were aware of their deficit intentionally focused on neglected space as a compensation. Therefore, it could be difficult to say whether there is actually a functional recovering if only pencil-and-paper tests are used. To overcome this dissociation between clinical and everyday situation, Baking Tray Task asked to place 16 blocks (the “buns”) as evenly as possible on a board (the “tray”), just as they were to bake real buns. They further considered an unbalanced disposition towards the right side of more of two buns as pathological, or in other words, sign of neglect.

Practical advantages and psychometric properties of BTT. BTT is easy and quick to administer and it isn’t tiring for the patient, since it requires little cognitive load. Nevertheless, it seems to correctly detect patients with neglect from mild to severe, while other tests could fail to discriminate between spatial impairment and compensation strategies. Thanks to its undefined nature (that is, there aren’t any predetermined spatial configurations of the buns) BTT seems to be unaffected by practice effects [1], or by demographic variables like age, education and gender [6]. Lastly, BTT showed a good test-retest reliability [7] in that 90% of the buns were put in the same side of the tray. In the same study, it was also developed a laterality bias which expresses the laterality of BTT buns distribution in percentage terms (leftward bias value: -12,5%; rightward bias value: 18.7%), overcoming the calculation of a score only in terms of left-right difference.

BTT does not seem to be associated to other spatial tasks like cancellation (line, letter and dots), figure copying or bisection [8] [1] suggesting that each task refers to different neuropsychological aspects. However, Bailey, Riddoch and Crome [7] found a good correlation with Star Cancellation Test and Line Bisection Test.

Additional data about validity could be useful, so these directions will be discussed later on.

2.2 Technology enhancement: E-BTT

Recently, Cerrato and colleagues [9] [10] developed a technology enhanced version of Baking Tray Task, using the platform E-TAN (which is for *tangible*). E-TAN is a useful tool made up of the software and hardware platform that allows to use tangible interfaces. In place of cubes, uses 4 cm disks, while the tray measures 60x45 cm and it's delimited by a wooden frame. ArUco Markers tags are applied to frame corners and disks [11] in order to let the camera (a 30-fps camera placed on top of the board at a fixed distance and connected to a laptop computer), detect the disks and the four corners of the tray. By doing this, the software can collect the coordinates of each disk, as well as temporal sequence [10] [12] [13]. One benefit of this new task (now called E-BTT) is the enhancement of the ecological validity, since it refers to daily familiar situation (the disposition of objects in a defined space such ad cookies on a tray) combined with an enrichment of the information obtained [14].

Fig. 1. Materials of the E-BTT. On the top-right: the E-TAN platform

This enhanced version of the Baking Tray Task allows not only to discriminate between patients and healthy subject, but also to investigate spatial exploration patterns in healthy subjects, including explored area and temporal sequencing of objects in space. In addition, the E-BTT board requires patients to reach further in the left space than during typical paper-and-pencil tests [4].

3 Potentialities and possible research questions

Although Baking Tray Task in its original version is quite mature, E-TAN and E-BTT are at their first steps. They have been developed just years ago and need more data and validation. Here we examine some new directions which E-BTT could apply to. By proposing these future directions, we wanted to focus on using E-BTT on healthy patients, rather than for clinical purposes. We think that the newly added information and data can help us understand normal brain functioning, other than neglect deficits. That is why we have chosen to talk about only new research projects that involve healthy subjects.

Indeed, placing objects in near space is a task we perform everyday automatically – book on a shelf, pens in a mug, cookie dough ball on a tray. So, discovering more details about how we process the space around us – the space which we can act in – can be revealing of something deeper.

3.1 Algorithms of data analysis: literature and future directions

In its novelty features, E-BTT changes the type of data that researchers are called to analyze: no more frequencies (how many cubes on the right and how many on the left, using the middle body line), but coordinates. This change raises new statistical demands. But first of all, we need to see how they have been treated until now.

As for the original version of BTT, first thing to do is to count the number of cubes that the subject has placed on one side and then subtracting it to the number of cubes to the other side; this simple formula can give us a quick clue about the presence of a spatial bias. Another simple equation has been developed by Facchin and colleagues [6]. It gives back a percentage of the laterality bias, which can result more sensitive than the simple difference between cubes on the left side and cubes on the right side (see also [4]).

Another simple approach can be dividing the space in four section, or quadrants, and count the cubes that lie in each of them [9]; then a Pearson Chi square statistic can reveal significative differences in frequencies of each quadrant.

The methods described above, however, do not fully exploit the information given by E-TAN platform, that is spatial coordinates and temporal disk sequences. Although this is a problem far to be resolved, we aim to clarify already used data analysis algorithms and propose new ones.

The same research team which developed the E-BTT also proposed clustering of spatial trajectories through Principal Component Analysis (see [13], for more details). This cluster analysis revealed the presence of three groups: the first starts to place the disks from several different positions, following no definite plan. The second group is made up of those subjects who starts from the right but goes also to the left in a periodic movement. Finally, the third group starts from the left side.

On a higher level, a new method was proposed later [4], starting from the idea of analyzing the explored area delimited by the 16 disks. Considering each of them as the vertices of a polygon, the convex hull area described was calculated through the Monte Carlo integration algorithm. Differentiating the area on the left and on the right side, this method can discriminate neglect patients from healthy participants.

Taken together, these researches did not fully use the E-BTT potential. Traditional statistics used in psychology are not meant to take account into spatial or temporal sequences, so our effort is to search for an alternative and effective data analysis algorithm which allow us to use available information thoroughly.

A valid response to this need seems to come from artificial intelligence. Neural networks are information elaboration systems [15] that could be very useful when it comes to complex data. They could learn from experience – that is, the data given to it – modifying their links according to learning rules. Neural networks learn gradually and require a large amount of information, though. So, our primary goal should be to collect more subjects.

3.2 Verticality and spatial exploration

Verticality is the position of an object along the vertical axis. Vertical position is associated with different abstract constructs such as power, concreteness, valence, rationality/emotions, direction [16].

For example, [17] found that people were quicker to recognize stimuli representing power (i.e. pictures labeled “master” or “servant”) when these appeared near the top of the screen, and slower when the stimuli representing power were represented in the bottom. These results were interpreted as an index for the mental association strength: quicker reaction times meant stronger relationship [16]. According to this interpretation, Meier and Robinson [18] found that participants were quicker to categorize positive words when these appeared at the top of the screen, whereas the opposite were true for the negative words (shorter reaction time when they appeared at the bottom).

While the laterality (right vs left) of spatial exploration has been widely discussed (mostly regarding neglect syndrome and its deficits: from that BTT was developed), little is known about vertical disposition of things. Only few studies made the subjects actually “move” or “manipulate” verticality of objects.

Giessner and Schubert [19] conducted a series of experimental sessions about vertical location and judgment of leaders’ power. In two of them, they asked participants to place a box that represented a manager or a leader into an organizational chart. They were previously informed about the power the manager/leader held in that organization. Powerful leaders were placed in the organization chart significantly higher as compared to non-powerful leaders.

In a series of studies carried by Cian, Krishna and Schwarz [20], the relationship between the conceptual metaphor rationality/emotion and verticality was proved. In the pilot, subjects located rationality in the head of a human silhouette, while emotions are indicated to reside in the heart. Later on, they asked participants to place two kinds of section in a blank website square. They found that the music section (which was rated as the most emotional section) was placed at the bottom, while the science section was placed higher, proving that the connotations of stimuli can affect their spatial placement.

Until now, y-axis data of the E-BTT disks have not been computed or analyzed, except in Cerrato and colleagues [9], in which the enhanced version of BTT was used. A clear tendency to put the first cube/disk in the upper part of the tray was found. Therefore, it could be interesting to analyze the vertical pattern of the disk, besides their laterality.

It would be really interesting analyzing vertical axis exploration with this new tool; conceptual metaphors (power, negative/positive, emotion/rationality) could be manipulated and their effects on vertical disposition can be explored. Vice versa, the effect of disposing objects higher (vs lower) on the way subject process them can be explored.

In conclusion, vertical information in an innovative task like E-BTT can give an additional insight on visuospatial abilities and how a person explores and processes the world around them. The relationship between verticality and conceptual word is another example of how the human cognition is somehow embodied in action.

3.3 Stress and spatial exploration

Some studies have found that stress can have an impact on spatial cognition both in animals [21][22][23] and humans [24] [25] [26], although the definition of stress can be different across all studies. A recent study linked pseudoneglect (the tendency to start from the left or to the deviate to left in different spatial task, see also [27]) to the COVID-19 lockdown stress in Italy [26]. Results showed that during the quarantine participants deviates further to the left in a digital cancellation task. Moreover, this bias was associated with the ratings on an ad-hoc scale of stress. These results, however, are just explorative; further research can link the potential effect of stress/social isolation on spatial exploration.

Indeed, a stressful situation like a quarantine can be demanding both because it requires each person involved new resources to deal with new challenges (e. g. smart working, work-family balance) both because it asks people to dramatically reduce their social life. Differentiating between these two (note that these could be only two of the many possible causes of stress) could help us understand better the underlying mechanisms that affect spatial cognition.

In line with these hypotheses, we could manipulate cognitive load with some stressful tasks (like the one used by [24]) and examine how the performance to the E-BTT changes: in particular, our research interest could be either the verticality or the laterality, or both of them. Otherwise, an ostracism or isolation manipulation task could be administered to participants, like putting them in a socially isolated (vs socially challenging) virtual situation. In both cases, the E-BTT could be administered as a within or a between factor. Given the undefined nature of the possible spatial disposition, a within design can be validly applicated to both cases.

A possible hypothesis is that in experimental condition subjects begins and dispose disks lower than controls. According to the above-mentioned literature it could be hypothesized that stress can lead to explore only the bottom part of the space – like a focus on the space nearer to the body (that can have an evolutionary meaning). Further data are needed to clarify these points.

3.4 Explored area and possible associations

The explored area –calculated as in Cerrato and colleagues [4] – can be associated with several psychological aspects such as personality. Thus, new experimental perspective could be drawn by the analysis of the explored area.

One could also talk about stress, imagining that in a stressful situation, cognitive resources can be impaired by the need to process and explore the area nearer us in order to better respond to dangerous stimuli. So, it could be that stressful situations are associated with narrower areas. Or vice versa, it might be safer to explore the space around or near the anchors (in the case of E-BTT, the wooden frame), so stress can be associated with wider areas (because the disks are placed along the frame, forming greater polygons).

Interesting hypothesis could come from the developmental psychology. Ainsworth, Bell, and Stayton (as cited in [28]) have found that individual differences in security of attachment may affect exploration patterns: securely attached children balanced exploration with proximity seeking while anxious/avoidant showed either little proximity seeking or little exploration in exchange of proximity searching. Coherent with this, Hazen and Durrett themselves found that securely attached children scored higher on tasks on spatial ability. This could suggest that attachment styles in adulthood can reflect in how much space they take up when they have to place objects around them. Maybe the area described is bigger when they are securely attached – since they explore more.

In a study [29], participants who scored higher (lower) in neuroticism or depressive symptoms responded to or detected lower (higher) regions of visual space more quickly. Another [30] found that navigational performance in a virtual learning task was influenced by anxiety and psychoticism. Finally [31] highlighted how depressed patients performed worse than controls in a virtual reality task, measuring a lower number of locations found. Could it be that anxiety and depression symptoms can impair spatial exploration of the peri-personal space too? And from a different standpoint, how emotions and mood influence spatial patterns?

We then can conclude that the innovative idea to measure the convex area described by the disks could be the starting point of many new research questions. Little is known about the amount of space really occupied when exploring and placing objects. Manipulating emotion, stress and other psychological variables could yield useful information on spatial cognition.

3.5 Reading habits and handedness

We have already mentioned the tendency to start spatial exploration from the left side, a phenomenon known as pseudoneglect [27] [14] [26]. This leftward bias has been found in different tasks such as bisection [32] [33], cancellation [14] and placing objects [4][14]. An important factor which researchers should be aware of is that maybe this tendency could be due to the reading habit and thus to cultural backgrounds. For example, Chokron and Imbert [34] found that Israeli subjects bisected the line to the right of the objective center, while French subjects placed their subjective middle to the left of the objective one, according to the direction of the reading preferences (left-to-right for French and right-to left for Israeli). Similar results [35] came out comparing monolingual and bilingual readers: according to their mother-tongue reading habits, results showed that monolingual readers deviated leftward (for left-to-right), or rightward (for right-to-left); bilingual readers show no significant bias.

An interesting point came from Rinaldi and colleagues [36] who administered the star cancellation task to preschoolers and second graders (before and after reading abilities acquisition). Results showed a leftward bias in the cancellation of the first target and in visual search; these biases increased from preschoolers to second graders. Furthermore, they tested the role of handedness, proving that left-handed children showed a rightward oriented visual search, although the overall distribution of attention was again biased to the left. These results cannot be explained neither by the neurobiological hypothesis (that is, the right hemisphere is dominant in the control of visuospatial attention: [36] [37]) nor by the cultural one, but only by an interaction between them.

According to these findings it could be possible, thanks to the E-BTT, to further explore the possibility that reading direction could shape visuospatial exploration in the peri-personal space. One interesting point could be to differentiate different patterns in different culture, that is, administering E-BTT to subjects that read right-to-left or up-to-down (like Japanese or Chinese). As this regard, it's worth noticing that Asian languages uses an alphabet based on logographic or syllabic units. This means that they can be written either horizontally or vertically. Thus, Asian people can have a cultural flexibility that could reflects on how the explore the space around them.

Another perspective can come from brain laterality. Many of the studies examined here are on right-handed subjects; little is known about left-handers. Possible new directions should focus on how left-handers and the hand used in the task can change spatial patterns.

4 Conclusion

As we have seen, Baking Tray Task, administered through the E-TAN platform, is a new tool developed by Cerrato and colleagues combining new technologies (e.g. tangible interfaces) with a classical neuropsychological test. The novelty of this innovations stands in new type of data, that describes spatial patterns and temporal sequences. Of course, as is often the case, this raises new challenges for researchers, who are called to answer more and more complex questions. Here we have examined some of them, but many others could be proposed, as long as new data are collected.

So, in summary, E-BTT is a versatile tool which opens to many research possibilities and potentialities. Aside a further validation, several variables could be investigated: verticality, handedness, reading habits, stress, mood, emotions.

Addressing these variables could improve not only our understanding of spatial cognition, but it could also have implication on economy, marketing, business and developmental psychology.

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References

1. Gibson, J., J.: The ecological approach to visual perception. Houghton Mifflin, Boston (1979).
2. Bartolomeo, P.: Visual neglect. Current opinion in neurology, 20(4), 381–386 (2007).
3. Tham, K., Tegnér, R.: The baking tray task: a test of spatial neglect. Neuropsychological Rehabilitation 6(1), 19–26 (1996).
4. Cerrato, A., Pacella, D., Palumbo, F., Beauvais, D., Ponticorvo, M., Miglino, M., et al.: E-TAN, a technology-enhanced platform with tangible objects for the assessment of visual neglect: A multiple single-case study. Neuropsychological Rehabilitation (2020).

5. Takamura, Y., Imanishi, M., Osaka, M., Ohmatsu, S., Tominaga, T., Yamanaka, K., et al.: Intentional gaze shift to neglected space: a compensatory strategy during recovery after unilateral spatial neglect. Brain, 139(11), 2970–2982 (2016).
6. Facchin, A., Beschin, N., Pisano, A., Reverberi, C.: Normative data for distal line bisection and baking tray task. Neurological Sciences, 37(9), 1531–1536 (2016).
7. Bailey, M. J., Riddoch, M. J., Crome, P.: Test–retest stability of three tests for unilateral visual neglect in patients with stroke: Star cancellation, line bisection, and the baking tray task. Neuropsychological Rehabilitation, 14(4), 403–419 (2004).
8. Menon, A., Korner-Bitensky, N.: Evaluating unilateral spatial neglect post stroke: working your way through the maze of assessment choices. Top Stroke Rehabilitation; 11(3):41-66 (2004).
9. Cerrato, A., Ponticorvo, M., Gigliotta, O., Bartolomeo, P., Miglino, O.: Btt-scan: uno strumento per la valutazione della negligenza spaziale unilaterale. Sistemi intelligenti, 31(2), pp. 253–270 (2019a).
10. Cerrato, A., Ponticorvo, M., Gigliotta, O., Bartolomeo, P., Miglino, O.: The assessment of visuospatial abilities with tangible interfaces and machine learning. In International Work-Conference on the Interplay Between Natural and Artificial Computation. Springer: Berlino, Heidelberg, pp. 78–87 (2019b).
11. Garrido-Jurado, S., Muñoz-Salinas, R., Madrid-Cuevas, F. J., Marín-Jiménez, M. J.: Automatic generation and detection of highly reliable fiducial markers under occlusion. Pattern Recognition, 47(6), 2280–2292 (2014).
12. Gentile, C., Cerrato, A., Ponticorvo, M.: Using technology and tangible interfaces in a visuospatial cognition task: the case of the baking tray task. In Miglino, O. & Ponticorvo, M. (Eds.), Proceedings of the First Symposium on Psychology-Based Technologies co-located with XXXII National Congress of Italian Association of Psychology - Development and Education section (AIP 2019), Naples, Italy, 25-26 September, 2019, volume 2524 of CEUR Workshop Proceedings. CEUR-WS.org (2019).
13. Palumbo, F., Cerrato, A., Ponticorvo, M., Gigliotta, O., Bartolomeo, P., Miglino, O.: Clustering of behavioral spatial trajectories in neuropsychological assessment In SIS 2019-Smart Statistics for Smart Applications, (pp. 463–470). Pearson (2019).
14. Somma, F., Argiuolo, A., Cerrato, A., Ponticorvo, M., Mandolesi, L., Miglino, O. et al.: Valutazione dello pseudoneglect mediante strumenti tangibili e digitali. Sistemi Intelligenti (in press).
15. Floreano, D., Matiussi, C.: Manuale sulle reti neurali. Bologna: Il Mulino (2002).
16. Cian, L.: Verticality and Conceptual Metaphors: A Systematic Review. Journal of the Association for Consumer Research, 2(4), 444-59 (2017).
17. Schubert, T. W.: Your Highness: Vertical Positions as Perceptual Symbols of Power. Journal of Personality and Social Psychology, 89 (1), 1–21 (2005). cit. in [16].
18. Meier, B. P., Robinson, M. D.: Why the Sunny Side Is Up: Associations between Affect and Vertical Position. Psychological Science, 15 (4), 243–47 (2004).
19. Giessner, S., R., Schubert, T., W.: High in the Hierarchy: How Vertical Location and Judgments of Leaders' Power Are Interrelated. Organizational Behavior and Human Decision Processes, 104 (1), 30–44 (2007).
20. Cian, L., Krishna, A., Schwarz, N.: Positioning Rationality and Emotion: Rationality Is Up and Emotion Is Down. Journal of Consumer Research, 42 (4), 632–51 (2015).
21. Brydges, N. M., Hall, L., Nicolson R., Holmes, M.C., Hall, J.: The effects of juvenile stress on anxiety, cognitive bias and decision making in adulthood: a rat model. PLoS One. 7:10 (2012).

22. ter Horst, J. P., de Kloet, E. R., Schächinger, H., Oitzl, M. S.: Relevance of stress and female sex hormones for emotion and cognition. Cellular and molecular neurobiology, 32(5), 725–735 (2012).
23. van der Kooij, M.A., Jene, T., Treccani, G., Miederer, I., Hasch, A., Voelxen, N., et al. : Chronic social stress-induced hyperglycemia in mice couples individual stress susceptibility to impaired spatial memory. Proceedings of the National Academy of Sciences, 115 (43) E10187-E10196 (2018).
24. Richardson, A. E., VanderKaay Tomasulo, M. M.: Influence of acute stress on spatial tasks in humans. Physiol Behav. 103:5, 459-466 (2011).
25. Schwabe, L., Oitzl, M. S., Philippsen, C., Richter, S., Bohringer, A., Wippich, W., et al.: Stress modulates the use of spatial versus stimulus-response learning strategies in humans. Learn Mem. 14:1, 109-116 (2007).
26. Somma, F., Bartolomeo, P., Vallone, F., Argiuolo, A., Cerrato, A., Miglino, O., et al.: Further to the left. Stress-induced increase of spatial pseudoneglect during the COVID-19 lockdown. PsyArXiv (in press).
27. Bowers, D., Heilman, K. M.: Pseudoneglect: Effects of hemispace on a tactile line bisection task. Neuropsychologia. 18:4-5, 491–498 (1980).
28. Hazen, N. L., Durrett, M. E.: Relationship of Security of Attachment to Exploration and Cognitive Mapping Abilities in 2-Year-Olds. Developmental Psychology. Vol. 18, No. 5, 751-759 (1982).
29. Meier, B. P., Robinson, M. D.: Does 'Feeling Down' Mean Seeing Down? Depressive Symptoms and Vertical Selective Attention. Journal of Research in Personality, 40 (4), 451–61 (2006).
30. Walkowiak, S., Foulsham, T., Eardley, A. F.: Individual differences and personality correlates of navigational performance in the virtual route learning task. Computers in Human Behavior, Volume 45, Pages 402-410 (2015).
31. Gould, N. F., Holmes, M. K., Fantie, B. D., Luckenbaughet, D. A., Pine, D. S., Gould, D. S., et al.: Performance on a virtual reality spatial memory navigation task in depressed patients. Am J Psychiatry. 164(3):516-519 (2007).
32. Gigliotta, O., Malkinson, T. S., Miglino, O., Bartolomeo, P.: Pseudoneglect in visual search: Behavioral evidence and connectional constraints in simulated neural circuitry. eNeuro, 4(6), ENEURO.0154-17.2017 (2017).
33. Jewell, G., McCourt, M. E.: Pseudoneglect: a review and meta-analysis of performance factors in line bisection tasks. Neuropsychologia. 38:1, 93-110 (2000).
34. Chokron, S., Imbert, M.: Influence of reading habits on line bisection. Brain research. Cognitive brain research. 1(4):219-222 (1993).
35. Rinaldi, L., Di Luca, S., Henik, A., Girelli, L.: Reading direction shifts visuospatial attention: An Interactive Account of attentional biases. Acta Psychologica, 151, 98–105 (2014).
36. Rinaldi, L., Di Luca, S., Toneatto, C., Girelli, L.: The effects of hemispheric dominance, literacy acquisition, and handedness on the development of visuospatial attention: A study in preschoolers and second graders. Journal of Experimental Child Psychology, 195:104830 (2020).
37. Thiebaut de Schotten, M., Dell'Acqua, F., Forkel, S., Simmons, A., Vergani, F., Murphy, D. G. M., et al.: A lateralized brain network for visuospatial attention. Nature Neuroscience. 14, 1245–1246 (2011).