

## Embodied finger counting in children with different cultural backgrounds and hand dominance

Liudmila Liutsko<sup>a\*</sup>, Alexandr N. Veraksa<sup>b</sup>, Vera A. Yakupova<sup>b</sup>

<sup>a</sup>*Research Institute of Brain, Cognition and Behaviour (IR3C), UB, Spain*

<sup>b</sup>*Faculty of Psychology, Lomonosov Moscow State University, Moscow, Russia*

\*Corresponding author. E-mail: liudmila\_liutsko@yahoo.es

**Background.** Embodied finger counting has been shown to have cross-cultural differences in previous studies (Lindemann, Alipour, & Fisher, 2011; Soto & Lalain, 2008). However, their results were contradictory in reference to Western populations with regard to the hand preferred: The first study showed that in Western countries — Europe and the United States — participants preferred to start with the left hand (whereas in the Middle East — Iran — they used the right hand); the second study showed that participants in France preferred the right hand.

**Objective.** Our study aimed to observe these differences in two countries, Spain (Western Europe) and Russia (Eastern Europe part), although taking into account the variety of cultural or ethnic groups who live there.

**Design.** The observational/descriptive study, together with correlational analysis of the finger-counting pattern (from 1 to 10) used by children aged 10 to 12 who had not been taught to use their fingers for counting, considered factors of cultural origin and hand dominance. The possible effects of this action on cognition — in our case, math achievement — were considered also.

**Results and conclusion.** The differences in the frequency of the finger-counting patterns might suggest cultural-individual differences in performance; however, the correlational analysis did not reveal that these differences were statistically significant, either for gender or for mark in math. However, hand dominance was a significant predictor of the preferred hand with which to start counting.

**Keywords:** embodied numerosity, finger counting, cross-cultural research, individual differences, hand dominance

### Introduction

Rosenbaum (2005) mentioned that little attention had been paid to movement control in psychological research, naming this area the “Cinderella of Psychology,” and urging that it play a more important role in the future. Whereas linguistic tests encounter problems with exact interpretation when translated into other languages or

if they are missing values describing context with regard to different cultural views and perceptions, movements are more universal and less biased when we wish to compare results in cross-cultural studies. On the one hand, movements can follow an unconscious pattern when a person selects the optimal way to do something (Rosenbaum et al., 1991), sometimes even the same way in humans and animals. On the other hand, movements are related to perception, emotion, and cognition, in that there are individual differences (Rosenbaum et al., 2012; Liutsko et al., 2012; Iglesias et al., 2014; Liutsko et al., 2015).

Since culture and ethnicity are complex constructs and should not be manipulated to look for “superiority” in comparisons, it has been suggested to compare variables that are distinct in these cultures and thus to consider cultural differences as a set of variables of individual differences (Gasquoine, 1999). Previous studies have shown some individual differences between representatives of different cultures in fine motor skills (Liutsko & Tous, 2014) and memory (Gutchess & Inneck, 2009), among others. The better performance in fine motor skills and math in East Asian-American children was found to be significant, thus showing the predictive relationship of the construct in motor skills and math achievements (Luo et al., 2007).

Cultural differences in neuropsychological assessment are very important in occupational therapy and psychological work (Chui et al., 2007). In general, numerosity was found to have a similarity in the neural code across species (Piazza & Izard, 2009). However, in finger counting habits from 1 to 10, Lindemann, Alipour, and Fisher (2011) reported differences between Middle Eastern (Iranian) and Western individuals (European and American) that resulted in clear cross-cultural differences in the hand and finger starting preference. Whereas the first group preferred to start counting with the right hand and preferred to map the number 1 to their little finger, the second group preferred the left hand and the thumb. Another study in a French population aged 4 to 24 (Sato & Lalain, 2008), independently of the age group, revealed a strong tendency to use first the right hand to count from 1 to 5 and then the left hand to count from 6 to 10.

The embodied cognition framework revealed that neural systems for perception and action were engaged during higher cognitive processes; thus it was shown in fMRI studies that individual finger-counting habits modulate motor cortex activation to number processing (Tschentscher et al., 2012) and spatial-numerical associations (Fischer, 2008; Fischer & Brugger, 2011). Moeller et al. (2012) evaluated whether the concept of embodied numerosity should be generalized beyond finger-based representations, with particular focus on whether bodily-sensory experiences (such as moving the whole body along the mental number line) may correlate with numerical capabilities. In a previous review (Moeller et al., 2011), they discussed the results of various studies that revealed an important debate between neurocognitive researchers and mathematics education researchers concerning finger-based strategies for numerical development. They also mentioned that some recent studies supported the hypothesis that children with good finger-based numerical representations show better arithmetic skills and that training finger gnosis, or “finger sense,” enhances mathematical skills (Moeller et al., 2011), including in adults, supporting the general idea that abstract cognition in adults may at least partly be rooted in our bodily experiences (Klein et al., 2011).

Crow and colleagues, describing the effects of handedness on academic performance in children (age 11), did not report any differences between right-handers

and left-handers, but they mentioned some deficits in extreme right-handers and more substantial deficits with relatively similar hand use (ambidexters), those who were “at the point of hemispheric indecision” (Crow et al., 1998).

A study by Domahs et al. (2010) supported the idea that finger-counting habits affect how numbers are processed, with the assumption that this effect is culturally modulated. Bender and Beller (2012) argued that the different types of finger counting all constitute distinct representational systems and explored the cognitive implications of their properties, such as encoding information and representation, ease of learning and mastering a system, and memory retrieval and cognitive load, with suggestions for future research in the field of embodied cognition.

The aim of our exploratory study was to observe qualitatively the patterns by which children use their fingers in counting with regard to hand dominance and cultural background, in two countries, with Western and Eastern European culture and possible different ethnic subgroups. A complementary task was a quantitative analysis to check whether there are any statistically significant correlations between the finger-counting patterns and culture, gender, or marks in math.

## Method

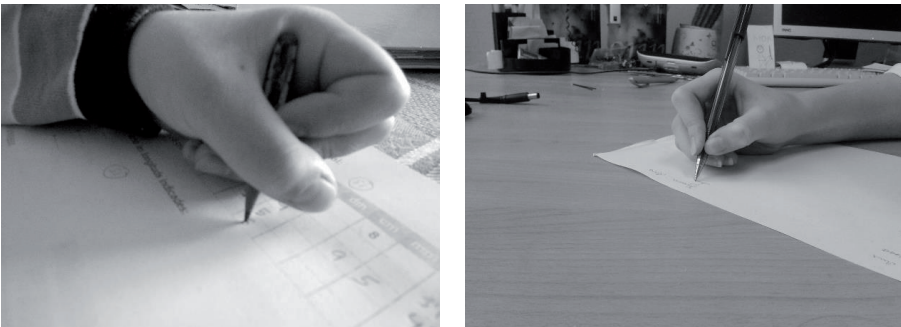
### *Participants*

One hundred and twenty children, aged from 10 to 12, of whom 53% were males and 93% were right-handed, from different cultural backgrounds and with their permanent residence in either Spain or Russia, participated in this study. Informed consent was given by their parents and themselves. Their cultural-ethnic origins (about 12% of parents were of mixed cultural groups) were the following: 49% Russia (native); 40% Spain (native); 1-5% Belarus, Ukraine, Israel, Azerbaijan, Armenia, Georgia; and less than 1% Morocco, Japan, India.

### *Instruments and methodology*

The children were tested and registered individually with the following instructions:

- 1) “Please, write your name” (or the child’s writing was just observed during class or when doing homework, to confirm which hand is dominant).



**Figure 1.** Checking for the active hand in writing (left-hander and right-hander)

Source: Pictures by Liutsko, L. (left: Spain) and Yakupova, V. (right: Russia).

## 2 “Could you count from 1 to 10 using your fingers, please?”



**Figure 2.** Finger-counting test (opening fingers, on the left; closing fingers, in the middle; and pointing with the index finger of the other hand, on the right).

Source: Pictures by Liutsko, L. (left: Spain) and Yakupova, V. (middle and right: Russia).

None of the children used or had been taught to use their fingers in counting, either at home or in school. Additional information (cultural background, hand use, grades in math) was obtained from their parents and teachers. The data were processed by Excel and SPSS v.19. *Compliance with Ethical Standards:* All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study.

## Results

Children aged 10–12, of whom 53% were males and 93% right-handed, participated in Spain and Russia in the test of finger counting from 1 to 10. Their cultural-ethnic origin (about 12% of parents were of mixed cultural groups) was the following: 49% Russia (native); 40% Spain (native); 1–5% Belarus, Ukraine, Tatarstan, Israel, Azerbaijan, Armenia, Georgia; and less than 1% Morocco, Japan, India.

Since the children were from the whole class/grade group, their marks in math (final mark of the previous semester) were heterogeneous and could reflect average population statistics: 22% “satisfactory,” 62% “good,” and 16% “excellent.” Of the pupils who received an “excellent” mark in math, the following is the percentage distribution for finger counting:

Representation of the number 1: with the thumb 23%; index finger 15%; little finger 62%; and of the number 6: thumb 54%; index finger 8%; little finger 38%.

Way of moving fingers: 69% opened their fingers, 30% closed them, and 1% used open hands and just pointed with the index finger of the other hand to move from one finger to another.

Right hand used to start counting: 87% in the Spanish-based population and 56% in the Russian one. No statistically significant difference was observed in the finger-counting pattern between the two main groups — Spain and Russia; neither cultural influence was statistically significant. 56% in Russia and 77% in Spain used the right hand to start counting; 59% in Russia and 65% in Spain started counting

with the thumb, followed by index, middle, ring, and little finger. The percentages of starting to count with the index finger were 12% in Russia and 6% in Spain; with the little finger, it was 32% and 17%, respectively. The patterns of starting with the thumb, index, and little finger for the number 6 by the other hand were 70% vs. 75%, 5% vs. 4%, and 23% vs. 21% in Russia and Spain, respectively.

Independently of which hand was dominant, the frequency of the pattern thumb-index-middle-ring-little finger in both hands was observed in 59% of families where parents belong to the same culture vs. 50% in heterogeneous (mixed) cultures. Correlational analysis performed for the whole group did not reveal any statistically significant correlation of the finger-counting pattern with such factors as cultural background, gender, or mark in math. However, the difference in the finger-counting pattern was statistically significant ( $\rho = .30, p = .009$ ) in relation to hand dominance. Other weak, but statistically significant differences were observed in the patterns of the finger used for the number 1 and the hand chosen to start, with a negative sign ( $\rho = .254, p = .028$ ) and between the patterns in fingers used for the numbers 1 and 6 (for different hands), with a positive sign ( $\rho = .291, p = .011$ ).

## Discussion and conclusion

Although the study was performed in two countries, Spain and Russia, the children represented such cultures as those of Spain, Russia, Japan, Morocco, Armenia, India, Belarus, Ukraine, Israel, Georgia, and Azerbaijan (all of them resided in either Spain or Russia). The most frequent pattern was to start counting using the thumb (the highest frequency observed with either hand), then to start with the little finger and the index finger (the least frequent, although nobody started counting with the middle or ring finger). This pattern is consistent with the results reported by Lindemann et al. (2011), obtained for Western countries, although the preferred hand to start with was the right one here for both Western (Spain) and Eastern (Russia) samples, with all 12 ethnic subgroups.

The preferred hand to start counting with was the right in the Spanish (Western) population, with 77% of total frequency, which coincides with the results of Lindemann et al. (2011) for the Middle Eastern group (Iran) (but not for Western one) and with French (Western) population results in the study by Sato et al. (2008). The Russian results in our study show that in 56% of cases the right hand was used to start and in 44% the left hand. Thus there is no clear preference as to hand in our study, which is comprehensible also since Russian culture is a kind of bridge between Western and Eastern cultures and combines parts of both cultures.

The differences in the frequency of the finger-counting patterns might suggest cultural-individual differences in performance; however, the correlational analysis did not reveal that these differences were statistically significant, either for gender or for mark in math. However, hand dominance was a significant predictor of the preferred hand with which to start counting: Taking into account the negative sign for relationship and the codification pattern used for the fingers (1 — thumb, 2 — index, 3 — middle, 4 — ring, and 5 — little finger), the results suggest that right-handers would prefer to start counting with the little finger and left-handers with the thumb. Moreover, the relationship between the fingers used to start in either



hand (for the numbers 1 and 6) was also statistically significant; since this correlation had a positive sign, the conclusion we derived is that it is more likely use the same finger to start. To sum up, the conclusion from this preliminary study is that we observed some cultural differences in finger counting from 1 to 10, and also in the percentage of which hand and finger was used to start. The preferred finger to start counting was the thumb, then the little finger, and least the index finger.

The pupils who had an “excellent” mark in math performed the preferred pattern for the whole group for numbers 6 to 10, although, the preferred pattern for numbers 1 to 5 was to start from the little finger (higher percentage in use). However, these differences were not confirmed by correlational analysis and a statistically significant relationship was shown only between finger-counting pattern and hand dominance. Further studies with more participants are required to determine the cross-cultural and hand dominance effects on finger-counting patterns.

### Acknowledgements

The study was supported by a grant from the Russian Science Foundation (project № 16-18-00073).

### References

- Bender, A., & Beller, S. (2012). Nature and culture of finger counting: Diversity and representational effects of an embodied cognitive tool. *Cognition*, *124*(2), 156–182. doi: 10.1016/j.cognition.2012.05.005
- Crow, T.J., Crow, L.R., Done, D.J., & Leask, S. (1998). Relative hand skill predicts academic ability: Global deficits at the point of hemispheric indecision. *Neuropsychologia*, *36*(12), 1275–1282. doi: 10.1016/S0028-3932(98)00039-6
- Chui, M.M.Y., Ng, A.M.Y., Fong, A.K.H., Lin, L.S.Y., & Ng, M.W.F. (2007). Differences in the fine motor performance of children in Hong Kong and the United States on the Bruininks-Oseretsky test of motor proficiency. *Therapy*, *17*(1), 1–9. doi: 10.1016/S1569-1861(07)70002-5
- Domahs, F., Moeller, K., Huber, S., Willmes, K., & Nuerk, H. C. (2010). Embodied numerosity: Implicit hand-based representations influence symbolic number processing across cultures. *Cognition*, *116*(2), 251–266. doi: 10.1016/j.cognition.2010.05.007
- Iglesias, T., Liutsko, L., & Tous, J.M. (2014). Proprioceptive diagnostics in attention deficit hyperactivity disorder. *Psicothema*, *26*(4), 477–482.
- Fischer, M. H. (2008). Finger counting habits modulate spatial-numerical associations. *Cortex*, *44*(4), 386–392. doi: 10.1016/j.cortex.2007.08.004
- Fischer, M.H., & Brugger, P. (2011). When digits help digits: Spatial–numerical associations point to finger counting as prime example of embodied cognition. *Frontiers in Psychology*, *2*. doi: 10.3389/fpsyg.2011.00260
- Gasquoine, Ph.G. (1999). Variables moderating cultural and ethnic differences in neuropsychological assessment: The case of Hispanic Americans. *The Clinical Neuropsychologist*, *13*(3), 376–383. doi: 10.1076/clin.13.3.376.1735.
- Gutchess, A.H., & Indeck, A. (2009). Cultural influences on memory. *Progress in Brain Research*, *178*, 137–150. doi: 10.1016/S0079-6123(09)17809-3
- Klein, E., Moeller, K., Willmes, K., Nuerk, H.C., & Domahs, F. (2011). The influence of implicit hand-based representations on mental arithmetic. *Handy Numbers: Finger Counting and Numerical Cognition*, 68.

- Lindemann, O., Alipour, A., & Fischer, M. H. (2011). Finger counting habits in Middle Eastern and Western individuals: An online survey. *Journal of Cross-Cultural Psychology*, 42(4), 566–578. doi: 10.1177/0022022111406254
- Liutsko, L., Tous, J.M., & Muiños, R. (2012). The effects of proprioception on memory: A study of proprioceptive errors and results from the Rey-Osterrieth Complex Figure in a healthy population. *Acta Neuropsychologica*, 10(4), 489–497.
- Liutsko, L. & Tous, J.M. (2014). Sex and cultural differences in proprioception based on fine motor performance. *Personality and Individual Differences*, 60 (Supplement), S29. doi: 10.1016/j.paid.2013.07.050
- Liutsko, L., Tous, J.M., Veraksa, A., & Leonov, S. (2015). Proprioceptive indicators (precision, speed and personality) of age-depended differences for traffic security. *Procedia — Social and Behavioral Sciences*, 187, 491–496. doi: 10.1016/j.sbspro.2015.03.092
- Luo, Z., Jose, P.E., Huntsinger, C.S., & Pigott, T.D. (2007). Fine motor skills and mathematics achievement in East Asian American and European American kindergartners and first graders. *British Journal of Developmental Psychology*, 25(4), 595–614. doi: 10.1348/026151007X185329
- Medland, S.E., Duffy, D.L., Wright, M. J., Geffen, G.M., Hay, D.A., Levy, F., ... & Boomsma, D.I. (2009). Genetic influences on handedness: Data from 25,732 Australian and Dutch twin families. *Neuropsychologia*, 47(2), 330–337. doi: 10.1016/j.neuropsychologia.2008.09.005
- Moeller, K., Fischer, U., Link, T., Wasner, M., Huber, S., Cress, U., & Nuerk, H. C. (2012). Learning and development of embodied numerosity. *Cognitive Processing*, 13(1), 271–274. doi: 10.1007/s10339-012-0457-9
- Moeller, K., Martignon, L., Wesselowski, S., Engel, J., & Nuerk, H.C. (2011). Effects of finger counting on numerical development — the opposing views of neurocognition and mathematics education. *Frontiers in Psychology*, 2, 75–79. doi: 10.3389/fpsyg.2011.00328
- Piazza, M., & Izard, V. (2009). How humans count: Numerosity and the parietal cortex. *The Neuroscientist*, 15(3), 261–273. doi: 10.1177/1073858409333073
- Rosenbaum, D.A., Chapman, K.M., Weigelt, M., Weiss, D.J., & van del Wel, R. (2012). Cognition, action, and object manipulation. *Psychological Bulletin*, 138(5), 924–946. doi: 10.1037/a0027839
- Rosenbaum, D.A., Slotta, J.D., Vaughan, J., & Plamondon, R. (1991). Optimal movement selection. *Psychological Science*, 2(2), 86–91. doi: 10.1111/j.1467-9280.1991.tb00106.x
- Sato, M., & Lalain, M. (2008). On the relationship between handedness and hand-digit mapping in finger counting. *Cortex*, 44(4), 393–399. doi: 10.1016/j.cortex.2007.08.005
- Tschentscher, N., Hauk, O., Fischer, M. H., & Pulvermüller, F. (2012). You can count on the motor cortex: Finger counting habits modulate motor cortex activation evoked by numbers. *Neuroimage*, 59(4), 3139–3148. doi: 10.1016/j.neuroimage.2011.11.037

*Original manuscript received September 23, 2016*

*Revised manuscript accepted December 02, 2016*

*First published online November 30, 2017*