

University of Bologna

December xxth, 2022

Valter Prpic, PhD

Department of Philosophy and Communication Studies

University of Bologna

Telephone Number: +39 051 20 9 2221

Email: valter.prpic@unibo.it

**Manuscript re-submission**

Dear Editors,

We want to thank you and the reviewers for very positive comments on our manuscript “Contrasting symbolic and non-symbolic numerical representations in a joint classification task” submitted by Valter Prpic, Yasmine A. Basamh, Courtney M. Goodridge, Tiziano Agostini and Mauro Murgia. We have now addressed all the comments and revised the manuscript accordingly. We found the comments of the reviewers very helpful, and we are confident that the manuscript has been improved. Our reply to the reviewers’ comments and the changes made to the manuscript have been explained in detail in the following section of this letter.

In brief, we expanded the discussion regarding the phenomenon of global/local processing (Navon, 1977) and we showed why we are confident that this phenomenon did not influence our findings. Similarly, we explained why we decided to use structured non-symbolic displays and a limited numerosity range. We also explained why we believe that separate analyses for symbolic and non-symbolic numerals are clearer and more appropriate in this paper. Finally, we have followed the editor/reviewer’s suggestions and provided the descriptive statistics in the appendix. All the minor comments/changes have also been addressed and implemented in the manuscript. By completing all the changes we have done our best to be succinct and we have only exceeded the 3000-word limit by less than 10%.

All the changes in the manuscript have been highlighted in red to facilitate the revision process at this stage. We are confident that the manuscript has now been improved and that it deserves publication in Psychonomic Bulletin & Review. Due to its theoretical implications, we believe that our work will have a substantial impact on the research in the field and will inform future research.

We look forward to hearing from you soon and thank you for your consideration.

Sincerely yours,

Valter Prpic on behalf of the authors

We report our replies to reviewers in **blue** ink, while the changes made in the manuscript are marked with **red** ink.

Reviewer Comments to Author (if any):  
Reviewer: 1  
  
Comments to the Author  
The authors tested if SNARC effects can be elicited, similarly, by symbolic and non-symbolic numerals. Participants completed an online experiment in which they were asked to classify as smaller than or greater than 3, symbolic numerals (digits 1,2,4, and 5), or the number of elements presented within a square. In both cases, visual stimulation was the same, with the task instruction varying between conditions (ie, responding to the numeral magnitude of the number of stimuli). The main results show that a SNARC effect emerged for the symbolic, but not for the non-symbolic, condition.  
  
The paper is well written and organized, the data are accessible and the sample size is justified by power analysis; methods and tasks are sound. I have one main comment and a couple of smaller ones.  
  
a. I have found the task introduced by the authors smart and elegant; however, my own understanding suggests that response behavior was different between the two conditions, given that digits and numerosity call different perceptual mechanisms into account (local and global, as honestly reported also on page 17). This is likely an intrinsic characteristic of this task that cannot be overcome with additional experiments controlling for local/global differences, but I would invite the authors to be a bit more convincing when explaining that local and global processing would not have any effect here.

We thank the reviewer for the very positive opinion on our manuscript and for highlighting some points of improvement. Regarding local/global processing, we realized that the previous version of our manuscript was not sufficiently clear. Based on the reviewer’s suggestion we have further discussed this point and made clear that there is no evidence that local/global processing affected the presence/absence of spatial numerical associations in our study. Indeed, based on the Navon paradigm we specified that an interference could only be expected for global over local processing, thus when we required digit (i.e., local) processing in the symbolic task. However, we found no evidence that the SNARC effect for digits was affected by numerosity (i.e., global).

Conversely, according to Navon local processing should not affect global processing. Therefore, digits should not affect the processing of numerosity. Indeed, in the non-symbolic task we found no influence of local over global stimuli, supporting the idea that the absence of the SNARC effect in the non-symbolic task should not be due to local interference. Furthermore, we suggested future studies to investigate the phenomenon of global precedence in the SNARC effect by using combinations of digits in order to systematically investigate both local and global number processing. We are confident that the editor and the reviewer will find this point adequately addressed in the revised version of the discussion.   
  
As minor thoughts:  
  
b. I am not familiar with the guidelines of this journal concerning word limits, but I would report all the results provided by the analyzes. For instance, in Experiment 1 please report the main effect of the hand and the values associated with the non-significant interactions; moreover, please report the values of the t-tests after the significant interaction; same approach for Experiment 2.

Considering that the word limit for a brief report is stringent we decided to only report the main findings in the text. However, we agree with the reviewer about the importance of having the full results available for the readers. Therefore, we made available the complete output of the study on the project page on Open Science Framework (<https://osf.io/e7rj3/>), together with the data and the analysis script.We have also uploaded them in the supplementary materials that will be available online.  
  
c. The graphs are great and clear in reporting your main results, but I would like to see a table containing all mean data for all conditions.

We agree with the reviewer about the importance of providing descriptive statistics to the reader. Therefore, we decided to add the tables containing all means and standard errors in the Appendix.  
  
  
Reviewer: 2  
  
Comments to the Author  
Summary  
  
In this study, the authors sough to test whether the SNARC effect interacts between symbolic and nonsymbolic numeral formats. Using a novel task design, they tested 52 adults’ ability to classify the symbolic value of a digit and the quantity of dice-like patterns of digits when symbolic and nonsymbolic information were congruent or incongruent. They found evidence of a SNARC effect when participants classified symbolic numerals whether or not nonsymbolic information was congruent. They also found no evidence of a SNARC-like effect when participants classified nonsymbolic numerals whether or not symbolic information was congruent. Overall, the authors conclude that these findings provide evidence the ANS and ATOM theories and for distinct representations of numerical formats.  
  
The authors appear to appropriately follow the Psychonomic Society statistical guidelines.  
  
The manuscript is well written and provides clear and concise results and interpretations. Below I raise 3 concerns that when thoroughly addressed may improve the quality of the manuscript, and I point out several minor issues that can be easily addressed.  
  
Relatively major  
  
1.      The authors have chosen a relatively narrow number range, presumably for consistency in mapping quantities to ‘dice-like’ patterns. It would helpful if the authors provide a clearer motivation for why they chose this narrow range of numbers. The extant literature cited suggests that numerals 1-9 should have been considered. The authors also correctly mention that symbolic numerals are thought to be represented linearly, but nonsymbolic numerals to be represented logarithmically. Is it possible that the exclusion of 7, 8 , & 9 bias nonsymbolic processing in a way that doesn’t affect symbolic processing? In other words, could the quantities used here affect the ability to detect a SNARC-like effect in nonsymbolic numeral processing? I encourage the authors to (at minimum) elaborate on the brief mention of this in their limitations section.

We thank the reviewer for the positive view on our work and for the suggestions that helped us improve the manuscript. There are several reasons why we chose a narrow 1-5 range. 1) As the reviewer correctly points out this range is consistent with the typical numerosity of dice patterns. 2) Although SNARC literature usually employs the entire single digit range (1 to 9) Dehaene et al. (1993) already demonstrated that the SNARC effect is flexible and it depends on relative (rather than absolute) numerical magnitude. Indeed, they tested both a 0-5 and a 4-9 range showing that numbers 4 and 5 were responded faster with the right when they were the largest values and with the left when they were the smallest values of the range. So, the exclusion of some numerical values is not supposed to bias the SNARC effect. 3) There is evidence that the SNARC effect for non-symbolic numerals is stronger in the subitizing range (Mitchell et al., 2012). The interpretation of the authors is that an approximate representation of numbers shows increasing noise with increasing magnitude. Therefore the representation of small numerals is precise while with larger numerosity there is lower likelihood to have a precise representation. Therefore, we should exclude that the use of small quantities prevented the SNARC effect to be detected as we were expecting quite the opposite. 4) Finally, we used a small numerical range as we wanted numerosity to be processed as similarly as possible to digits and to have overall comparable response times. Indeed, numbers in the symbolic form are recognized almost instantly while the RTs in the non-symbolic form increase with increasing magnitude. Therefore, we thought that numerosity close to the subitizing range would better fit our purpose to be recognized similarly to digits. Thanks to the reviewer’s comment we realized that this point deserved further discussion and we accordingly modified the text, both in the method and more extensively in the discussion.

2.      The authors mention their results could be driven by the structure or the nonsymbolic numerals. They also mention in the introduction that the SNARC-like effect is found in structured and unstructured patterns of nonsymbolic numerals. But it is unclear why they decided to go with only structured. Why not unstructured? I raise this because the results suggest the presences of competing numerical information (opposite format) impacted overall reaction time, but not the SNARC effect. Is it possible that interference could have been stronger and affective if the stimuli were not organized in a meaningful way? Perhaps the authors can shed some light on this issue in the discussion where they discuss the global vs. local processing bias, seeing as an unstructured nonsymbolc numeral display would disrupt global processing and perhaps bias local processing.

This is an interesting point and, together with the issue on the range of the stimuli, we have briefly explained why we tested structured non-symbolic numerals in a small range. We do not believe that specific hypotheses could be made regarding the use of unstructured non-symbolic numerosity, but we explicitly encourage future studies to address this.   
  
3.      Why did the authors not include symbolic and nonsymbolic measures in the same model? While I agree that the data and analyses presented provide evidence of a SNARC effect in the attend symbolic but not non-symbolic conditions, a stronger test of this (and to provide an effect size for future work) would be to test this directly in on model. I don’t have a particularly strong opinion of this, as it would be difficult to interpret a 4-way interaction, it does seem as though this analysis would be valuable given the short report format.

As the Reviewers suggested we have also considered the idea of including both symbolic and non-symbolic tasks in the same model, but we have several reasons that convinced us to treat these as separate experiments with separate analysis. One is that the use of a single model would make the interpretation of lower order interactions extremely difficult. Another reason is linked to statistical power. Indeed, including a task type factor in the model would create a 2 x 2 x 2 x 2 RM ANOVA and the sample of participants required to test for a 4-way interaction would be consistently larger that the samples typically tested in the literature. Finally, we also think that processing symbolic stimuli (digit) highly differs from judging the numerosity of an array of items therefore we believe that the two tasks should be treated as separate experiments rather than be included in the same model.   
  
Minor  
  
1.      Pg 6, line 110, “focussed" should be “focused”

Corrected.  
  
2.      Pg 10, line 206-208, this sentence is slightly confusing. Perhaps rewording to say explicitly how long the blank screen and fixation cross were presented could reduce this confusion.

We modified the sentence, and we clearly specified the duration of each component.  
  
3.      Pg 10, line 209, “the keyboard response was activated” is confusing. The participant should be responding using the keyboard. Do the authors instead mean the response prompt?

We agree that this sentence was confusing, and we modified it to avoid misunderstandings.

4.      Pg 11, top, it could help the reader if the authors labeled each condition and block. For example, when the numerical information was “congruent” or “incongruent” and attend to the “symbolic” or “nonsymbolic” numerals, etc. This would also allow the authors to refer to which conditions they are describing in the following paragraph when they reference “the order of the two conditions”

We have now clearly labelled each condition (which we now called task for consistency with the rest of the paper) and we believe that this made of procedure clearer. Conversely, we decided not to label the blocks because we think that using congruency/incongruency with to SNARC effect to name the key assignment could create more confusion to the reader.

5.      Pg 12, line 237, could the authors please indicate how many subjects contributed to the 304 outlier trials, and on average how many outlier trials subjects had?

We have now reported this information in the text.  
  
6.      Pg 13, line 269, find = found

Corrected.  
  
7.      Pg 15, line 323-324, this sentence is confusing. Please consider rewording for clarity.

Modified.