STRUCTURAL SIMILARITIES BETWEEN NATURAL LANGUAGES AND ARTIFICIAL LANGUAGES IN THE DOMAIN OF COLOR AND THEIR IMPACT ON COMMUNICATION: A LARGE-SCALE ONLINE STUDY

THOMAS F. MÜLLER[*1], JAMES WINTERS[1], TIFFANY MORISSEAU[1], IRA NOVECK[2], and OLIVIER MORIN[1]

[*]Corresponding Author: tmueller@shh.mpg.de
[1]Minds and Traditions Research Group, Max Planck Institute SHH, Jena, Germany
[2]Institut des Sciences Cognitives – Marc Jeannerod, CNRS, Lyon, France

Artificial language studies have well established that structure in language can arise through a tradeoff between compressibility and the functional need for expressivity (Kirby, Tamariz, Cornish, & Smith, 2015). This structure is what allows language to reduce continuous meaning spaces to discrete signals (Carr, Smith, Cornish, & Kirby, 2017), which in turn enables interlocutors to communicate successfully. One issue that has received little attention here is about the possible similarities between the structure evolving in the artificial language and natural language (even though the potential problem has been recognized early on: cf. Kirby, Cornish, & Smith, 2008). Given that participants are already fluent in at least one native language before they use the artificial one, the extent of potential biases remains unclear (cf. Xu, Dowman, & Griffiths, 2013). In this study, we focus on the domain of color, which is an example of a continuous meaning space that has been of major interest for scholars of language in the past (e.g. Berlin & Kay, 1969). Specifically, we ask: i) How closely does artificial language structure resemble the one for color terms in natural language? and ii) Are there measurable effects of this structure on performance and usage of the artificial language?

We address these questions by analyzing the data resulting from the 1-year runtime of an online smartphone application that was designed to create an artificial language. Access to the application was free and it was disseminated worldwide. The game asked participants to communicate a target out of an array of four colors to their partner, who then had to try and guess the correct color. For communication, participants were limited to using a set of black-and-white symbols only, which was provided for them at the start of the game. These

symbols were selected such that they had no obvious and unambiguous relation to one color only (cf. Fig. 1 for all symbols).

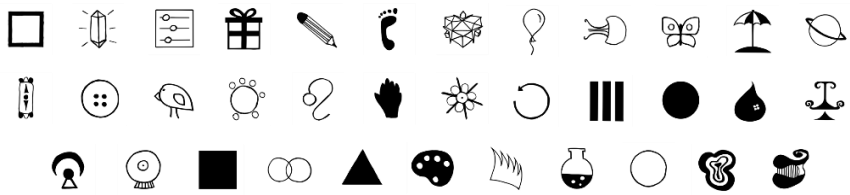

Figure 1. The 35 black-and-white symbols that players unlocked throughout the game.

Overall, we acquired data from over 4000 unique participants in this way. Crucially for our purposes, the game had been translated into 8 different languages. In this study, we need same-language participant pairs, which is why we focus on speakers of English (101 pairs), German (116), and French (44). Since we needed to ground our analyses in the structure these three languages exhibit for the 32 colors used in the game, we conducted an additional, separate study first. This was a naming task not unlike the World Color Survey (Cook, Kay, & Regier, 2005), but implemented online and with our specific color set, with 50 participants for each language.

We started our analyses by applying exploratory factor analysis to the basic color terms used in the naming task, revealing the structure in participants' native languages. The factorial structures we see (see Supplementary Material for an example) reflect the basic color terms well for English and German, but for French one unexpected factor emerged. With this baseline, we could proceed to test our predictions (pre-registered on the Open Science Framework). By applying confirmatory factor analysis, we tried to replicate the exploratory results on the artificial language data from our communication game. The results indicated at least a moderate fit for all languages, with the best outcome for German. Afterwards, we applied separate mixed-effects models to assess the effects of the individual structures found for the languages on performance and the number of symbols that participants sent. For English, we found that participants both had a harder time communicating and sent more symbols when the task presented them with colors that loaded on the same term in the factorial structure, as predicted. For German and French, no such effects could be found. These results show that the structure of artificial languages can resemble the one in natural languages, at least to some degree, and that this common structure affected both performance and usage of the artificial language, albeit only for English pairs. This implies that stimuli used in artificial languages have to be carefully tailored to participants' native languages, and that – in the bigger picture – potential biases arising from the native language should not be ignored.

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