What smartphone apps may contribute to language evolution research

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Summary. Unlike a standard online experiment, a gaming app lets participants interact freely with a vast number of partners, as many times as they wish. The gain is not merely one of statistical power. Cultural evolutionists can use gaming apps to allow large numbers of participants to communicate synchronously; to build realistic transmission chains that avoid the losses of information that occurs in linear chains; to study the effects of partner choice as well as partner control in social interactions. We are releasing an app designed to take advantage of these opportunities and generate realistic language evolution dynamics.

The "Color Game" app, available for Android and iOS smartphones, invites its users to play a referential communication task: one player guides another player who needs to pick a target colour within a set of four colours. Communication takes place through black and white symbols that have no clear pre-established meaning. The game's challenge consists in establishing shared significations for these symbols. The pool of players is divided into independent groups, which we expect to evolve distinct codes (or "languages") to solve the task. The app aims to study a series of six hypotheses relating to the formation of these synthetic languages, and to their use for referential communication. These range from language evolution research (are phylogenetic reconstructions of linguistic history valid?) to experimental pragmatics (studying, for instance, implicatures or common ground) and cultural evolution.

To avoid biasing players, these six hypotheses have not been made public, but they have been registered on the Open Science Framework, along with a full protocol explaining

how we intend to test them. These documents will be released one year after the launch of the game. A general description of the app and the scientific project that inspired it has already been published, along with the app's source code (Morin et al. 2018). These documents will later be joined by the full dataset obtained from the app users. The data will be completely anonymized, containing no identifying information. This letter briefly reflects on the reasons that made us prefer to collect our data with an app, rather than a crowd-sourced experiment.

Calls for a "smartphone psychology" (Miller 2012) or a "computational cognitive revolution" (Griffiths 2015) regularly invite cognitive and social scientists to make use of the new tools offered by so-called "pervasive ubiquitous computing". Apps and social networks, in contrast to more standard digital tools like online questionnaires or libraries, allow researchers to collect abundant data on a long-term basis, getting access to participant behaviour almost around the clock. This has made them popular in psychology, chiefly among clinicians who can use them to help and monitor patients in ways that would be too costly for standard human interventions (Fitzpatrick, Darcy, and Vierhile 2017). In comparison with this therapeutic use, smartphone apps designed to generate data for fundamental research are rather under-developed and under-used in the behavioural sciences. Promising exceptions have been developed for cognitive psychology, for psychometric purposes or to document demographic profiles for various standard psychological experiments (Lathia et al. 2017; Brown et al. 2014; Klindt, Devaine, and Daunizeau 2017).

Why have app-based experiments not been more widely adopted? The data generated by apps and social networks are usually proprietary and are increasingly less accessible to research as users demand more privacy and companies start monetising their data. The growing displacement of text by videos and pictures also means the data generated by apps and social networks are becoming "unstructured" (*sensu* Gandomi & Haider, 2015): they increasingly require special mining techniques like automated image or speech recognition to become analysable. Faced with these issues, most researchers have turned to online experiments or questionnaires, often relying on cheap labour from crowdsourcing services such as Amazon's "mechanical turk". Doing so allows scientists to scale up their experiment and gain statistical power, without damage to the quality of the resulting data (Casler, Bickel, and Hackett 2013). Satisfactory though it may be for most researchers, the crowdsourcing of experiments arguably misses quite a few opportunities afforded by the digital revolution.

Experimental language evolution is a case in point. It aims to reproduce some features of language evolution, under laboratory condition and using artificial languages, usually generated by participants playing referential communication games where often the

synthetic languages go through transmission chains (Scott-Phillips and Kirby 2010). This method yields robust, replicable claims that naturalistic observations would reach with difficulties (Kirby et al. 2015). However, arbitrary constraints limit the method's capacity to simulate linguistic interactions in a realistic way, even with crowdsourcing. App-based data collection may lift three such limitations.

- *The trade-off between synchrony and large samples.* Synchronous interaction is a crucial dimension of most human communication (Enfield 2017). Key features of linguistic interactions break down when two interlocutors cannot be present inside the same timeframe, like turn-taking and repair (Clark and Wilkes-Gibbs 1986; Dingemanse et al. 2015). Most language evolution experiments can only study synchronous interactions on a very small scale due to practical restrictions on the number of participants that can be studied. An app-based approach can lift this burden.

- *Closed vs. open transmission chains*. Transmission chains are a key aspect of experimental language evolution and cultural evolution research since the 1930s (Bartlett 1932; Mesoudi and Whiten 2008). The standard and widely emulated transmission chain set-up is a game of Telephone where a participant A is asked to transmit a content to B, then B is asked to do the same with C, and so on. Each subject is typically required to transmit a cultural content to one other subject, contrary to real life where agents freely choose whether to transmit a given content, and how many people to transmit it to (Morin, 2015: 122–130). Linear transmission chains, where each participant has exactly one interaction with one other participant, invariably lead to severe losses as information from upstream chain cannot be recovered (Claidière & Sperber, 2010, Morin 2015). Lastly, the generational turn-over simulated by laboratory chains is a far cry from realistic demographic dynamics. Solving these issues require open-ended transmission chains, but these are difficult to create and monitor in controlled conditions outside the lab, where strict limits are imposed on the number of participants.

- *Partner control vs. partner choice*. Language evolution experiments invariably pair participants with one or a few partners they must communicate with. A participant faced with an obtuse partner has no choice but to try and teach them better tools for communication; finding a more suitable partner is not an option. A parallel with the "evolution of cooperation" literature seems apt here. Experimental studies of helping, cooperation, or reciprocity among humans are dominated by economic games where two randomly assigned partners must choose how to share a resource or whether to cooperate to generate a common good. Success or failure depends entirely on "partner control", behavioural ecologists' name for all the actions that encourage or discourage a given partner from cooperating (Noë and Hammerstein 1994). Yet real-life cooperation also hinges on "partner choice", the switch from less cooperative partners to more cooperative

ones. A "market for cooperation" thus allows the most reliable partners to co-opt one another. Taking this dimension into account has recently lead to important theoretical advances in the study of human cooperation (Baumard, André, and Sperber 2013). Introducing partner choice in experimental language evolution may lead to similarly momentous changes, but here again the practical constraints of experiments (crowdsourced or lab-based) stand in the way. Gaming apps could clear the path.

Appendix 1: The general presentation of the game and registered studies can be found on the Open Science Framework, http://osf.io/g4kqs/

Appendix 2: The app's source code can be found on this GitHub repository: https://github.com/ColorGameMPG/ColorGame

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