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Overview of research interest

I am originally a mathematical biologist and used to work on mathematical models of genetic evolution; however, my interest gradually shifted to cultural evolution and social sciences. For a full list of my publications which includes those cited in this document, see the following website:

https://www.researchgate.net/profile/Yutaka-Kobayashi/research

For the last decade or so I have been working on the research on the cultural evolution of human technology (Kobayashi and Aoki, 2012; Kobayashi et al., 2018, 2021) as well as gene-culture coevolution (Kobayashi and Wakano, 2012; Kobayashi and Ohtsuki, 2013; Tamura et al., 2015; Kobayashi et al., 2015, 2016, 2019; Ohtsuki, et al., 2017) mainly through mathematical modeling but also through statistical analyses of archaeological or ethnographic data (Nishiaki et al. 2021; Nakamura et al., 2019). Through these studies I have been tackling several different but interrelated topics, one among which is the effects of demography, population structure, and the pathways of knowledge transmission on the rate of technological growth. Here, by technology I mean quite a broad range of phenomena, including stone tools, fishing nets, mobile phones, and even artificial intelligence. I consider the cultural evolution of technology particularly worth studying because humans' remarkable ecological success is largely attributable to culturally transmitted technologies for subsistence (like sewing needles in cold environments) rather than physical superiority or individual intelligence. Obviously, inventions do not accumulate without being transmitted over generations through social learning, and scientists can make breakthroughs only by standing on the shoulders of giants. Likewise, whether we can survive future threats, including resource depletion and climate crisis, depends on the path along which we grow our technologies.

Though my past studies are mostly theoretical as described above, recently I am interested more in conducting behavioral experiments to simulate the cultural evolution of technology in a laboratory or online, testing the predictions of mathematical/simulation models through the experiments, and fitting the models to the experimental data. The research field of cultural evolution is highly interdisciplinary, crosscutting biology, psychology, economics, archaeology, anthropology, and perhaps many other disciplines. So far, however, interaction between theoretical and experimental schools has been rather superficial presumably because of the difference in time scales they consider and in required research expertise. In this respect, I consider that my approaches are distinctive, combining rigorous mathematical/simulation models with laboratory/online experiments. In the following, some of my very recent studies (Nakawake and Kobayashi, 2022, 2024) and future plans along this line of research are presented for the convenience of potential candidates of Ph.D. students.

Laboratory experiments combined with models

In Nakawake and Kobayashi (2022, 2024), we conducted laboratory experiments in which participants engage in a computer-based task called the "virtual arrowhead task" [ref. 1]. This task is an established experimental paradigm, in which the participants are repeatedly asked to design a virtual arrowhead by adjusting the values of attributes (mainly width, height, and thickness). A well-designed arrowhead yields a higher reward in a hunting trip than those poorly designed, but participants are not informed about optimal attribute values, and in addition, a small noise is added to the performance score before it is displayed to the participants to simulate a realistic situation. Participants receive real monetary rewards according to the total payoffs they earned during the experiment. In N&K (2022) [ref. 2], we investigated how positive and negative social learning conditions promote the performance of participants and compared the results with theoretical predictions derived from computer simulations based on some adaptive learning algorithms. Here, in the positive (resp. negative) condition, participants are allowed once in every three trials to watch the scores and the attribute values of "other hunters" who are performing better (resp. worse) than the participants; they are virtual hunters generated by the computer, and the participants are informed about this fact. Therefore, the participants can copy or avoid the attribute values of the "others" in these occasions if they want. In theory, both information on successes and failures by others should be valuable for the participants. Accordingly, simulations predict that the performance of the participants may increase both in the positive and negative conditions under natural learning algorithms compared to the control condition in which no social information is presented, though the positive condition yields higher performance than the negative condition. Interestingly, however, in the experiment we found that only the positive condition, not the negative condition, resulted in significantly higher performance scores than the asocial control condition. This result suggested that humans are not very good at learning from others' failures but rather psychologically inclined toward copying others' behavior.

In N&K (2024) [ref. 3], we conducted a similar experiment to N&K (2022), but in the new experiment participants had to choose either of two options in every round: exploration of a new arrowhead design or exploitation of the existing arrowhead to get an immediate payoff. Accordingly, there was a time-allocation trade-off between exploration and exploitation. The new experiment also incorporated inter-generational transmission of the arrowhead designs. Namely, participants were randomly paired and played the roles as the first or second generation; each participant in the second generation inherited the final arrowhead design of the first-generation counterpart. In theory, the first-generation participants should invest a disproportionately larger effort in exploration if they are concerned about the success of the second-generation participants than if they are interested only in their own payoffs. We compared three conditions: (1) the asocial control in which there is no intergenerational transmission, (2) inter-generational transmission occurs, but the success of the second generation has no effect on the monetary reward to the first generation (unrepaid condition), and (3) the first generation receives an extra reward according to the success of the second generation (repaid condition). Theoretical models and simulations based on the premise of rational and selfish players predicted that the allocation of effort to exploration by the first generation increases in the repaid condition but not in the unrepaid condition compared to the asocial control. The experimental results conformed to this theoretical prediction, showing no increase in the investment in exploration by the first generation in the unrepaid condition. This consistency between the experiment and models was not trivial to us because we expected that participants in the first generation might be concerned about the second generation even without monetary incentive. This result suggests that humans do not have an instinct to invest an increased effort in exploration of new technologies in the presence of anonymous successors; monetary incentive, or perhaps a less anonymous situation, is needed to elicit an increased investment in technological exploration.

Ongoing and future projects

I am now most interested in studying the relationship between the cumulative cultural evolution of technology and intra- and inter-generational ethics. Novel technologies may help increase the total productivity of a society, but they do not necessarily help reducing the inequality among people; in fact, quite the opposite may well be the case in non-egalitarian societies. The emergence of property rights and the inter-generational transmission of privatized resources, which occurred contemporaneously with agriculture during the Neolithic revolution, resulted in an institutionalized system that allows the rich to become even richer and the poor to remain poor. One of my ongoing projects is aimed at revealing how technology fuels this inequality-expanding mechanism by means of a combination of laboratory/online experiments and mathematical/simulation models. Technology also drives inter-generational inequality without sensible control, spurring the current generation to short-term prosperity at the expense of the long-term well-being of the future generation. Human technology is creating many serious threats to humanity; nevertheless, it is also the technology that is required for us to survive these threats. Therefore, we can neither let it go free nor abandon it; it must be controlled so as to avoid bad scenarios. In future work, I would like to investigate the underlying mechanism by which technology drives intergenerational inequality and spurs a population of myopic players to extinction and also how we can avoid it.

Available facilities

Kochi University of Technology (KUT) has full-fledged experimental laboratories equipped with computers for running task programs in both campuses (Kami and Eikokuji) and a systematically managed local participant pool. These resources are available to Ph.D. students who wish to conduct cultural evolution experiments in KUT. Those who wish to conduct online experiments using participants from different or diverse ethnicities/nations need to resort to crowdsourcing platforms or consult with the supervisor to contact researchers who have access to a desired pool.

References

[1] Mesoudi, A. & O'Brien, M. J. (2008). The cultural transmission of Great Basin projectile-point technology I: an experimental simulation. American Antiquity 73, 3-28.
[2] Nakawake, Y. & Kobayashi, Y. (2022). Negative observational learning might play a limited role in the cultural evolution of technology. Scientific Reports 12, 970.
[3] Nakawake, Y. & Kobayashi, Y. (2024). Exploring new technologies for the future generation: exploration-exploitation trade-off in an intergenerational framework. Royal Society Open Science 11, 231108.