TOPICS
TOPICS IN COGNITIVE SCIENCE

Topics in Cognitive Science 0 (2021) 1–8

ISSN: 1756-8765 online
DOI: 10.1111/tops.12578

This article is part of the topic "The Cognitive Science of Tools and Techniques," Wayne D. Gray, François Osiurak and Richard Heersmink (Topic Editors). For a full listing of topic papers, see http://onlinelibrary.wiley.com/journal/10.1111/(ISSN)1756-8765/earlyview.

Editors' Introduction to Tasks, Tools, and Techniques

Wayne D. Gray,[a] François Osiurak,[b] Richard Heersmink[c]

[a]*Cognitive Science, Rensselaer Polytechnic Institute*
[b]*Laboratoire d'Étude des Mécanismes Cognitifs, Institut Universitaire de France*
[c]*Department of Philosophy, Monash University*

Received 27 August 2021; accepted 17 September 2021

Abstract

Tasks, tools, and techniques that we perform, use, and acquire, define the elements of expertise which we value as the hallmarks of goal-driven behavior. Somehow, the creation of tools enables us to define new tasks, or is it that the envisioning of new tasks drives us to invent new tools? Or maybe it is that new tools engender new techniques which then result in new tasks? This jumble of issues will be explored and discussed in this diverse collection of papers. Individually, few of the papers are related to each other by topic or by techniques of analysis. Collectively, all focus on tasks performed using tools and discuss the techniques of tool use which enable differences in performance and expertise across individuals, societies, and (even) species.

Keywords: Animal tool use; Constructing expertise; Extreme expertise; Varieties of artifacts; Teaming with your car; Brain; Mental imagery for motor acts; Foragers and their tools; Gestures; Tool embodiment; Spatial perception

1. Overview

Tasks, tools, and techniques—our daily lives are so enmeshed in these that it is sometimes hard to see our forest for our trees. Just as speaking is cognitively a different act

Correspondence should be sent to Wayne D. Gray, Cognitive Science Department, Rensselaer Polytechnic Institute, Troy, NY 12180, USA. E-mail: wayne.gray.psycsci@gmail.com

than is writing, so writing with a feather quill is both mechanically and cognitively different from writing with a pencil which is different in both ways from writing with an old Underwood typewriter which is different in many ways from writing with Microsoft Word on a modern computer which is very different for users of LaTeX. Of course, this is not to imply that the medium is the message as, in this case, it is not. Rather, the message is that we used to pause in some places not just to gather-our-thoughts but to take one page out of the typewriter and insert a blank page in. How much was our "attention to writing" devoted to keeping our quill-point sharp and our wet-ink blotted? When the typist paused to grab hold of the carriage-return lever and return it to the left-side of the typewriter, were those *pause-times* wasted in a merely mechanical action or was that time used to gather our thoughts and reflect, if ever so slightly, on our manuscript? That is, did such subtle differences in the tools of typewriting result in changes to cognition? While typing is a convenient example, the broader issue is whether and, if so, how our tools and our techniques for using our tools influence the products of our cognition? There are many ways of answering this question, and our 11 authors ask and answer it in, at least, 11 different ways.

The papers in this topic were written by researchers with a common interest in tool use—but the specifics of their research foci varies vastly from one research group to another. One paper brings a dynamic systems perspective to driver behavior that is all about being a part of *the tool of car driving* (Morris, Craig, & Mirman, 2021). Another worries about whether the evolution of symbolic language and tool use was independent or dependent on each other, and if so, whether the traces of these developments still remain in the human brain (Osiurak, Cretel, Uomini, Lesourd, & Reynaud, 2021). A third takes a cognitive psychology perspective to examine what our tools for professional sports, eating dinner, and other daily activities tell us about the role of expertise in tool embodiment (Weser & Proffitt, 2021). Another seeks to map the conceptual landscape of relations between the embodied mind and various artifacts (Heersmink, 2021). Yet another (Sterelny, 2021) explores the subsistence technology of forager communities in a discussion that evokes the stories of William Buckley and his life among the Australian aborigines in the early 1800s.[1] Another takes an *expertise perspective* to explore how the techniques that individuals develop for using the tools of Tetris lead some players to short, deadend plateaus while enabling others to leap to the next level of skill (Gray & Banerjee, 2021).

The above list of topics is not our limit. Others of our researchers find that blind cane users feel the curb not the cane itself and that tennis players feel the racket as a part of their body (Witt, 2021). One group of contributors is dismayed by the state-of-the-art in research on animal tool use and propose a very interesting reboot of that field (Colbourne, Auersperg, Lambert, Huber, & Volter, 2021). Another targets her report on "gestures as thinking tools" (Tversky, 2021). Lastly at the ultimate end of this list, the last paper we introduce here argues that our bodies are the *ultimate tool* (Rosenbaum, 2021) and that the key to understanding our use of more physical tools is to study the brain's control of the body.

2. A paper-by-paper introduction to our topics

2.1. Non-human tool use: Overrated or poorly defined?

The authors Colbourne et al. (2021) lead us into an important subfield of tool use in which a debate rages over what seems a reasonable proposal to address misconceptions regarding animal tool use by attempting to rationalize the rules of evidence. Our authors favor adopting the tooling (Fragaszy & Mangalam, 2018) framework to separate tool-use from non-tool-use activities in nonhuman animals. This framework views tooling as a specific category of tool use actions, which excludes actions, such as throwing or dropping a stone to break an egg, from this body-plus-object system. Colbourne et al. survey all tool-use examples documented by Shumaker, Walkup, and Beck (2011) and find that tooling appears to be phylogenetically less widespread than tool use with the variability being greatest in the primate order. Interestingly, the concept of tooling refers to an embodied process, which seems very close to some of the ideas presented by Weser and Proffitt (2021).

2.2. Varieties of artifacts: Embodied, perceptual, cognitive, and affective

Richard Heersmink maps the conceptual landscape of relations between embodied minds and various kinds of artifacts. Based on their functional properties, he identifies four categories of artifacts, namely motor, perceptual, cognitive, and affective artifacts. Embodied artifacts (e.g., hammers) are absorbed in the body schema and can feel like transparent extensions of the motor system. Perceptual artifacts (e.g., night vision goggles) are used to help us perceive or quantify the world better. They do so by correcting or amplifying our sensory capacities or by making visible and quantifying aspects of our world. Cognitive artifacts (e.g., maps) functionally contribute to performing a cognitive task such as, for example, navigating. Finally, affective artifacts (e.g., paintings) have the capacity to alter the affective state of the agent. These categories of artifacts do not have clear boundaries, but sometimes overlap. Mapping the landscape of relations between embodied minds and various kinds of artifacts provides us with a broader picture of humans as tool users, showing how humans use artifacts to achieve their aims, complete their tasks, and regulate their emotions. Heersmink's paper ends by identifying a number of trends regarding the use of these types of artifacts, focusing on neuroprosthetics, brain–computer interfaces, and personalization algorithms.

2.3. Expertise in tool use promotes tool embodiment

Veronica Weser and Dennis Profitt examine the curious but well-accepted phenomena that frequent use of a tool often results in it feeling as an extension of the hands or other body parts which use the tool. The more expert the user, the more intense this feeling. Hence, the often-used example of the blind walker's cane feels, to its blind walker, as if the tip of the cane is sensing the various up and downs of the path or smoothness or unevenness of the terrain. Indeed, according to Weser and Profitt, the cane allows blind users, "to integrate auditory and tactile information as they touch the area immediately in front of them with the cane's

tip." Perhaps even curiouser, the more expert the tool user is in using her tool, for example, a fencer's personal epee, the greater the discomfort felt when asked to use an unfamiliar epee. To a novice an epee is just a fancy name for a sword, but to the expert her personal epee is an extension of her arm. The last sentence of their paper stresses the importance of bringing the expertise perspective to tool use while also providing an apt summation of the authors' conclusions: namely "Expert effects in the tool-use literature signal the ways in which experts embody their tools in a manner more pronounced then has typically been documented in tool-use studies that do not employ experts" (Weser & Proffitt, 2021).

2.4. The expertise approach applied to Tetris: The limit is not the tool, but the techniques

In common with Weser and Profitt, Wayne Gray and Sounak Banerjee also adopt the *expertise approach* but their task is the classic game of NES Tetris. Simple objects do not imply simple techniques. For example, knowing the right technique to weave the right material could make all the difference in your ability to make a fishing net to feed your group. Likewise, if you were a NES Tetris player from the 1990s up until sometime in the 2010s, it is likely that your Tetris level of play had an upper limit of level 18 or, at the most, level 19. Today that limit is level 30 with recent discoveries (Macdonald, 2021), once mastered, expected to exceed that level. However, in their paper Gray and Banerjee do not focus on the extreme experts of the Tetris world but on a dataset of 492 students who played Tetris under laboratory conditions in which each move of a Tetris zoid was rated in terms of 35 features of Tetris play. The data were then teased and tortured until they revealed their structure to an exploratory factor analysis and then attacked with logistic regression tools to reveal changes in skill with expertise. Finally, the tools of linear-regression modeling were applied to determine structural differences among players at the same levels of expertise. The result is a study of how expertise is constructed not in one leap but by many tiny explorations and adjustments as new skills emerge.

2.5. Tool use affects spatial perception

In contrast to the two papers just introduced, Jessica Witt avoids on expertise per se to focus on the impact of virtual tools on spatial perception.

The *Pong effect* uses variations on the video game "Pong" and manipulates changes in paddle size to affect subjects' ability to block the virtual ball. One of the important and interesting aspects of this work is that changes in paddle size affect not just the players' likelihood of hitting the ball, but their estimate of the speed of the ball. Smaller balls were perceived as moving faster than larger ones. Witt's paper presents a detailed account of the various alternative hypotheses she and her collaborators considered and the various experiments they conducted which ruled out most of them.[2]

In general, the paper provides a readable and personal history of the development of research and theory in how tools change the "action capabilities" of people. We especially appreciated her discussion of J. J. Gibson's work (e.g., Gibson, 1933, 1941, 1977). Although Gibson stressed the importance of perception for action, he considered the main role of

perception to be the perception of possibilities for action, not spatial perception per se. We also liked her mention, almost in passing, of her very recent and, unfortunately, all too timely, discussion of how the nature of an object affects its perception. In that study, the task varied between identifying a gun being held versus identifying other objects. As she tells us, "When the object shown in the photograph was a shoe, participants were slower and less accurate to identify it when the participants held a gun than when they held a spatula (Witt et al., 2020). Wielding a gun makes a person a shooter, and shooters had a harder time identifying non-guns in the photographs."

2.6. Coevolution of tool behavior and language

François Osiurak, Caroline Crétel, Natalie Uomini, Chloé Bryche, Mathieu Lesourd, and Emanuelle Reynaud pursue the "shared neurocognitive processes hypothesis," which maintains that it was "the emergence of *the combinatorial component* of language skills" that "made possible the *complexification* of tool-making skills." This *technical-reasoning hypothesis* posits that reasoning, starting at a technical level, "creates a representation of the mechanical action appropriate to solve a physical problem." This representation biases the selection of motor actions that are used to realize the mechanical action." Interestingly, by this framework, manipulation knowledge is not needed to use tools.

The exploratory nature of their research is complemented by an extraordinary array of Supporting Information which provide a large, if not exhaustive, listing of 125 studies for the brain areas investigated in their paper (to be clear, this listing is in addition to the 126 references included in the Reference section of their paper). While we seldom become excited by such catalogs, in this case the listings emphasize the importance of the left posterior and parietal areas for an extraordinary number of cognitive tasks. Perhaps we are making a classic *where there is smoke there is fire* mistake but this listing, in addition to the references cited, increases our confidence in their association between language skills and the development of tool-making skills.

2.7. Driven to learn

One of the editors of this topic recently replaced his 15 year old car with a new one. Whereas his old car had a "cruise control," his new car has an "advanced driver assistance system" (ADAS) such as the ones discussed by Morris, Craig, and Mirman. During long drives on low traffic, three lanes in both directions, Interstate Highways, if left to itself (e.g., while the driver is listening to a podcast), the ADAS will gradually slow down to a cruising speed which matches the overly cautious car in the lane ahead (this "feature" is referred to by our authors as ACC or adaptive cruise control). Hence, before he knows it, our human driver (with ADAS) is driving 10 mph below the posted limit and his 90-min drive begins to turn into a 2-h one. Is this horrible? Well, of course not, but when asked, the driver reports that, all else equal, he would gladly abandon ADAS and return to the much more primitive (but predictable) cruise control on his previous, 15+-year-old car—a system that requires the driver to continually monitor the distance between his car and the car immediately ahead in

the same lane. On the other hand, these "dislikes" do not seem to be the inevitable result of "technology meets the nanny state." Rather, they seem more like a phase which our car technology (and drivers) are passing through. Hence, we are very hopeful that the Morris, Craig, and Mirman team will continue their research and continue working with their engineers so that our technology meets not just our needs but, also, our desires.

2.8. Foragers and their tools: Risk, technology, and complexity

Sterelny provides us with the details of a world that some of us never suspected existed. Namely a detailed look at ancient and modern foragers and the ways in which their lives were shaped by risk, technology, and complexity. The paper focuses on the late Holocene, which began approximately 11,650 years before the present and continues to this day. Spanning the breath of this era, Sterelny covers the beginnings of the Holocene from the ancient record as well as data collected from modern foragers living in the Canadian north or the Ju/'hoan Bushmen from Namibia.[3]

An interesting feature of Sterelny's paper is his discussion of the trio of *tasks, tools, and techniques*. The original fishhooks were not barbed. Which great genius was it who added the first barb to her fish hook? Would we call this the invention of a new tool? Or was it the discovery of a new technique? Can a technique be invented for a tool that does not yet exist? Or is it simply that every tool ever invented required an idea of how it would be used if it were made?

2.9. Thinking tools: Gestures change thought about time

Barbara Tversky starts her paper by playfully suggesting that, as a species, we change our name from *Homo sapiens* to *Homo faber*, the toolmaker or designer—we are a species that "makes an enormous variety of tools, primarily with our hands, and those tools make artifacts that enhance our well-being." Tversky's focus is on our *cognitive* tools, among which she includes gestures, language, and graphics. Interestingly, when it comes to *representational gestures*, form follows function; that is, gestures that signal a given action often mimic that action.

Four experiments are presented. All entail simple manipulations each of which has surprisingly strong effects. If the data were not so clear it would be hard to imagine that such simple manipulations, gesturing one way or another, could have such strong effects. Tversky has written a simple but incisive paper that deserves a deep reading.

2.10. The ultimate tool

David Rosenbaum leads us in an intellectual romp which starts with the assertion that the body itself "can be regarded as the ultimate tool." Hence, body movements can be regarded as tools for manipulating the body. This is an interesting, different, and *fun* way of thinking about familiar issues. Indeed if the ultimate tool is the brain and body, then we should be concerned with the two foundational issues which Rosenbaum addresses: namely choices

which are made with reference to motor imagery but without necessarily executing the move (Jeannerod, 1994, 2017) and choices based on evaluating candidate postures with respect to how well each posture satisfies current needs. The favored model does *not* use motor imagery or full simulation to "determine whether it would be wise to move one way or another. Rather, critical features of candidate positions, and critical features of candidate movements, are used to plan the acts to be performed."

Rosenbaum's view has interesting consequences. For example, if the set of features which are used to plan single displacements for a single limb are also used to plan "entire sequences of limb and body acts" than it may well be that distinct features do not just provide the core elements of perception, they also provide the core elements of action.

3. Summary

Tasks, tools, and techniques … the serial order of these three terms implies a logic that may or may not be supported by all authors in this special issue on tool use. Does the tool define or delimit the techniques by which it is used? Or, do the techniques determine the nature of the tool? Tools are simple! Techniques are discoverable or, maybe, inventable. Time and time again, even simple, 1-h long psychology laboratory studies lead individual subjects to discover new techniques for using simple tools to perform simple tasks.

Acknowledgment

The work was supported, in part, by grant N00014-16-1-2796 from the Office of Naval Research, Dr. Ray Perez, Project Officer.

Notes

1 See Henrich (2020) and McDonald (2021).
2 Of course, any discussion of the video game Pong, brings to mind the classic book, *Pilgrim in the Microworld*, by the famed ethnomethodologist, David Sudnow (1983).
3 Note that one editor remarks that he found the background provided by Chapter 2, of Joseph Henrich's (2020) book, *The WEIRDest People in the World*, aided in understanding some aspects of Sterelny's paper. That chapter begins with the story of William Buckley who in 1802, after deserting the Royal Navy, lived his next 25 years with members of the Wathaurung tribe of Australian aborigines.

References

Colbourne, J. A. D., Auersperg, A. M. I., Lambert, M. L., Huber, L., & Volter, C. J. (2021). Extending the reach of tooling theory: A neurocognitive and phylogenetic perspective. *Topics in Cognitive Science*, *12*(4).

Fragaszy, D. M. & Mangalam, M. (2018). Tooling. *Advances in the Study of Behavior*, *50*, 177–241. https://doi.org/10.1016/bs.asb.2018.01.001.

Gibson, J. J. (1933). Adaptation, after-effect and contrast in the perception of curved lines. *Journal of Experimental Psychology*, *16*(1), 1–31.

Gibson, J. J. (1941). A critical review of the concept of set in contemporary experimental psychology. *Psychological Bulletin*, *38*(9), 781–817.

Gibson, J. J. (1977). The theory of affordances. In R. Shaw & J. Bransford (Eds.), *The ecological approach to visual perception* (pp. 67–82). Hillsdale, NJ: Lawrence Erlbaum.

Henrich, Joseph (2020). *The WEIRDest people in the world*. New York, NY: Farrar, Straus, and Giroux. ISBN-13: 9781250800077

Jeannerod, M. (1994). The representing brain: Neural correlates of motor intention and imagery. *Behavioral and Brain Sciences*, *17*(2), 187–202. https://doi.org/10.1017/S0140525X00034026.

Jeannerod, M. (2017). *Consciousness of action*. https://doi.org/10.1002/9781119132363.ch41.

Macdonald, D. (2021). New NES Tetris technique: Faster than hypertapping! [Video]. YouTube. djpmacdonald@gmail.com. https://doi.org/10.1002/9781119132363.ch41 https://youtu.be/9RaqVGzhQTM

McDonald, M. (2021). The extraordinary tale of William Buckley: The great untold story of Australia's Robinson Crusoe.

Shumaker, R. W., Walkup, K. R., & Beck, B. B. (2011). *Animal tool behavior the use and manufacture of tools by animals*. Baltimore, MD: Johns Hopkins University Press. ISBN: 9780801898532

Sudnow, D. (1983). *Pilgrim in the Microworld*. New York, NY: Warner Books.

Papers in the Topic

Heersmink, R. (2021). Varieties of artifacts: Embodied, perceptual, cognitive, and affective. *Topics in Cognitive Science*, *13*(4):1–24.

Gray, W. D. & Banerjee, S. (2021). Constructing expertise: Surmounting performance plateaus by tasks, by tools, by techniques. *Topics in Cognitive Science*, *13*(4).

Morris, N., Craig, C. & Mirman, J. H. (2021). Tooling around town: Learning to drive with driver assistance systems. *Topics in Cognitive Science*, *13*(4):1–20.

Osiurak, F., Cretel, C., Uomini, N., Bryche, C., Lesourd, M. & Reynaud, E. (2021). On the neurocognitive coevolution of tool behavior and language: Insights from the massive redeployment framework. *Topics in Cognitive Science*, *13*(4).

Rosenbaum, D. A. (2021). The ultimate tool: The body, planning of physical actions, and the role of mental imagery in choosing motor acts. *Topics in Cognitive Science*, *13*(4):1–23. https://doi.org/10.1111/tops.12561

Sterelny, K. (2021). Foragers and their tools: Risk, technology and complexity. *Topics in Cognitive Science*, *13*(4):1–22.

Tversky, B. (2021). Thinking tools: Gestures change thought about time. *Topics in Cognitive Science*, *13*(4):1–27.

Weser, V. U. & Proffitt, D. R. (2021). Expertise in tool use promotes tool embod-iment. *Topics in Cognitive Science*, *13*(4):1–13.

Witt, J. K. (2021). Tool use affects spatial perception. *Topics in Cognitive Science*, *13*(4):1–18.