UOC Universitat Oberta de Catalunya   Universidad de los Andes Colombia

RESEARCH ARTICLE   **Open Access**

CrossMark

Magnetic and multistable: reinterpreting the affordances of educational technology

Jesper Aagaard (ORCID)

Correspondence:
jaagaard@psy.au.dk
Department of Psychology and
Behavioral Sciences, Aarhus
University, 8000 Aarhus C, Denmark

Abstract

The concept of affordances has become a popular analytical tool in educational technology. The present article, however, argues that the current understanding of affordances does not adequately address the use of educational technology and instead advocates a phenomenological reinterpretation. The article first introduces Gibson's concept of affordances and describes how scholars in the field of educational technology have invoked this concept to compile lists of technical action possibilities. It then argues that affordances do not just 'offer' a range of action possibilities; they actively 'invite' certain actions. To explore how such behavioral invitations manifest themselves in the everyday use of educational technologies, the article introduces the analytical concepts of multistability, relational strategy, and mediation and uses these concepts to analyze the affordances of laptops in the classroom. It is argued that laptops act as powerful attentional magnets that often invite students to become distracted. Theoretical and practical implications are discussed.

Keywords: Affordance, Educational technology, Habit, Multistability, Phenomenology

Introduction

In the past few years, Gibson's (2015) concept of *affordances* has become a popular tool in the field of educational technology (e.g., Conole & Dyke, 2004, Dalgarno & Lee, 2010, Song, 2011, Bower & Sturman, 2015). Although sympathetic to the general thrust of this ecological approach, the present article argues that employing a quasi-objectivist conceptualization of affordances as 'action possibilities' does not adequately address the everyday use of educational technologies. Instead, the article advocates a phenomenological approach that retains Gibson's direct realism, but adds concern for the so-called invitation character (*Aufforderungscharakter*) of affordances: Affordances do not simply *offer* a range of action possibilities; they actively *invite* certain actions. It is argued that this approach brings us closer to students' actual experiences of using digital technologies. The article first introduces Gibson's original notion of affordances and describes how scholars in the field of educational technology have used this concept as shorthand for 'action possibilities'. It then describes Hubert Dreyfus' critique of affordances and his phenomenological rehabilitation of their invitation character. To explore how such invitations manifest themselves in the everyday use of educational technologies, the article then introduces the analytical concepts of multistability, relational strategy, and mediation. Finally, these concepts are used to analyze the affordances of a ubiquitous educational technology: The laptop. Drawing

on empirical research, it is shown that laptops often invite students to become distracted and that students take precautions such as closing the lids of their laptops to resist this powerful invitation.

Gibson's concept of affordances

The concept of affordances originally stems from Gibson's (2015) ecological psychology. In his ecological studies of visual perception, Gibson's starting point was the active and mobile perceiver: "One sees the environment not just with the eyes but with the eyes in the head on the shoulder of a body that gets about" (p. 211). Based on such active exploration, the perceiver picks up information that is directly specified in the ambient optical array. This direct realism lead Gibson and his wife Eleanor Gibson (1955) to argue that information does not need to be stored in memory, since it is accessible in the environment. Accordingly, perception learning can (and should) be explained without invoking mentalist concepts: Perceptual learning does not happen through a mental *enrichment* of bare sensations with memory traces, but through an ever finer *differentiation* of previously vague impressions (this point applies across all perceptual systems, and the Gibsons gave the example of a wine connoisseur who is able to discriminate between claret, burgundy, and chianti). "Perceptual learning, then, consists of responding to variables of physical stimulation not previously responded to" (p. 34). This point dovetails with Latour's (2004) conceptualization of having a body as *learning to be affected*, which is exemplified through the perfume industry's use of odor kits to train apprentices in differentiating subtle fragrances. Ultimately, Gibson taught us that perceptual learning means learning to be affected by the world, getting increasingly attuned to its meaningful differences. His ecological psychology thereby stood in stark contrast to prevailing psychological theories, which understood the world as an aggregate of brute matter that human minds endow with meaning.

Gibson's project was to turn psychology's focus from the inner recesses of the mind to the richly textured and meaningful human environment. According to Gibson (2015), this environment consists of directly perceivable *affordances*, which he defined as follows: "The affordances of the environment are what it offers the animal, what it provides or furnishes, either for good or ill" (p. 119). Affordances are always taken with reference to an agent, which means that they are relative to species, physiology, development, and culture. To me, the pencil on my desk is not a brute chunk of wood and graphite, but a meaningful artifact that affords writing. Although still a meaningful artifact, the same pencil would not afford writing to a baby or a dog. Affordances are in turn enabled by an artifact's materiality such as its shape, size, rigidity, and so forth. If my pencil were broken, for instance, it would no longer afford writing, but it might still afford bookmarking or backscratching. Gibson further emphasized that all objects afford a multitude of actions: "The fact that a stone is a missile does not imply that it cannot be other things as well. It can be a paperweight, a bookend, a hammer, or a pendulum bob" (p. 126). Finally, to protect the concept of affordances from the perceived dualism of Gestalt theory, Gibson denied that affordances are defined in terms of their invitation character (*Aufforderungscharakter*) and described them as real and permanent features of the environment: "An affordance is not bestowed upon an object by a need of an observer and his act of perceiving it. The object offers what it does because it is what it is" (p. 130).

Affordances in educational technology

The concept of affordances has since been imported to the field of educational technology. Articles using an affordance-based framework are often built around the question: "What is the affordance of educational technology *X*?" (see e.g., Conole & Dyke, 2004, Dalgarno & Lee, 2010, Song, 2011, Bower & Sturman, 2015). When attempting to answer this question, scholars tend to use the concept of affordances as shorthand for 'action potentials' (Bower, 2008), 'possibilities for action' (Hammond, 2010), or 'action possibilities' (Antonenko, Dawson, & Sahay, 2017). In adherence to the idea of affordances as real and permanent features of the environment, such action possibilities are understood as technical features of educational technologies that enable and constrain certain actions. Conole and Dyke (2004), for instance, argue that digital educational technologies offer a wealth of action possibilities including access to rapidly changing information, exposure to diversity, and communication and collaboration. Bower (2008) similarly presents an extensive classification system for affordances that includes no less than 11 different categories: Media affordances (e.g., write-ability), spatial affordances (e.g., move-ability), temporal affordances (e.g., playback-ability), navigation affordances (e.g., search-ability), emphasis affordances (e.g., highlight-ability), synthesis affordances (e.g., combine-ability), access-control affordances (e.g., share-ability), technical affordances (e.g., speed), usability (e.g., intuitiveness), aesthetics (e.g., appeal), and, finally, reliability (e.g., robustness). Bower argues that singling out such inherent technical properties helps us avoid "any contextual biases that could be caused by the experience or culture of the user" (p. 5). While such lists may indeed contain very real and permanent technical features, they do raise the question of whether (and how) such 'action possibilities' are utilized in educational practice. In other words, do such deliberately decontextualized lists help us understand the everyday use of educational technologies?

In an article explicitly dismissing the usefulness of affordances in educational technology, Martin Oliver (2005) criticizes affordance lists for being confused and inconsistent. Unless one succumbs to an essentialist and positivist epistemology, he argues, cataloging possible affordances is a purely speculative endeavor: "'Possible' leaves nothing substantial to work with, unless a definitive list of possibilities can be constructed from the properties of each element separately, and their various interactions" (p. 403). Oliver goes on to dismiss the use of affordances *tout court*, since Gibson explicitly dismissed the mental realm and therefore provided unsatisfactory explanations for human learning. The concept of affordance may be adequate for species-level generalities, Oliver argues, but "people and learning are beyond it" (p. 412).[1] Jan Derry (2007) likewise protests the use of affordances in educational technology because of its roots in Gibson's direct realism. Drawing on the philosophy of John McDowell, Derry argues that direct perception cannot be transferred from the 'straightforward' question of animal perception to the 'complex' issue of human learning, because the distinctive feature of human engagement with the world is that it is conceptually mediated. Human beings are able to determine something *as* something (e.g., a door *as* a door) due to our enculturation into a conceptually structured space of reasons without which we would respond causally to our environment like a fire alarm responds to smoke. In both cases, Gibson's direct realism is critiqued for disregarding a 'higher' human level of cognition. While I agree that itemizing technical features does not tell us much

about how educational technologies are actually used in everyday practice, I do not subscribe to these mentalist critiques of the concept of affordances for reasons that will soon become clear. In what follows, I instead present a phenomenological approach to affordances that maintains Gibson's direct realism, but substitutes abstract 'action possibilities' with concrete use. The purpose of this reorientation is to shift focus from technical *possibilities* to what is *actually* going in the day-to-day realities of educational practice.

The phenomenology of responsiveness

Acclaimed phenomenologist Hubert Dreyfus has forcefully rejected McDowell's idea of a conceptually structured space of reasons as relying on a misleading myth of the mental (see Schear, 2013). According to Dreyfus (2007), humans absorbed in everyday coping experience the world nonconceptually, which means that we do not experience doors *as* doors, we just go through them. When pressing into possibilities, there is no conceptuality, no mindedness, and we simply move towards things that attract or repulse us. In making this argument, Dreyfus launches an interesting critique of affordances: Gibson's concept is not misleading due to its lack of conceptuality, but due to its peculiar status as "objective facts about what affords what" (p. 356). When responding to situations, however, we do not act on objective affordance-facts, but on *solicitations*, a Gestaltist term Dreyfus picks to convey how our surroundings are directly perceived as 'suggesting' or 'calling for' certain responses.[2] A handrail, for instance, suggests grinding to the savvy skater, while an extraordinary event calls for pictures. While Gibson's affordance-facts are somehow *out there*, at a distance from us, solicitations move us to act by drawing us in or pushing us away. The world of everyday coping, then, is not a disenchanted world of affordance-facts, but a vibrant web of attractions and repulsions. "Instead of the affordance-facts", Dreyfus argues, "it is the affordance's solicitations - such as the attraction of an apple when I'm hungry - to which I am directly open" (p. 357). Dreyfus thereby rehabilitates the invitation character of affordances: Affordances are magnetic entities that do not just *offer* a range of action possibilities, but actively *invite* specific actions (and repel others).

Dreyfus' reinterpretation of affordances is based on Maurice Merleau-Ponty's (2002) phenomenology of perception, which, like Gibson's ecological psychology, stresses the active, mobile, and embodied nature of perception. Also like Gibson, Merleau-Ponty argues that perception has no room for mediational epistemology and puts us in direct contact with the world (Dreyfus & Taylor, 2016). Finally, the Gibsonian idea that all experience is projected back into the world as increasingly rich differentiation is echoed in Merleau-Ponty's notion of an *intentional arc* (for examples of such Merleau-Pontyian connoisseur perception, see Ihde, 2015), but Merleau-Ponty (2002) crucially adds that our experiences invest the world with functional significances that pull us in certain directions: "The light of a candle changes its appearance for a child when, after a burn, it stops attracting the child's hand and becomes literally repulsive" (p. 60). The child experiences the hotness of the flame by burning her finger and this embodied understanding is henceforth present in her comportment towards lit candles. This example may imply a rather reflex-like notion of learning, but Merleau-Ponty's theoretical apparatus extends all the way to typing, sewing, and other forms of skillful coping

(Dreyfus, 2014) that solicit intuitive responses from involved agents. Phenomenology thus dispels the voluntarist dogma of most psychology: We often *feel immediately drawn* to act in certain ways (Dreyfus & Kelly, 2007).[3] "The body is no more than an element in the system of the subject and his world, and the task to be performed elicits the necessary movements from him by a sort of remote attraction" (Merleau-Ponty, 2002, p. 122). The question is how such solicitations manifest themselves in the everyday use of educational technologies. Here it is relevant to look at a contemporary school of thought called postphenomenology.

Studying human-technology-world relations

While naked perception involves a direct and unmediated 'human-world' relation, the use of technology extends this intentional relation into a 'human-technology-world' relation (Verbeek, 2005). Postphenomenology is a philosophy of technology that is concerned with such relations. It has its roots in classical phenomenology, but also draws on American pragmatism. As Ihde (2009) explains, the term postphenomenology was coined to sever connections to later Heidegger's one-size-fits-all account of Technology and to Husserl's subjectivist notion of consciousness. Instead, postphenomenology examines specific technologies in their particularities and subscribes to Merleau-Ponty's strong sense of embodiment. In short, it is empirical and materialist rather than metaphysical and idealist (Scharff, 2012). Some of its key concepts are multistability, relational strategy, and mediation. Firstly, a principal tenet of postphenomenology is the notion of *multistability*, which alludes to an artifact's various partially determined trajectories in different contexts (Rosenberger, 2016). Even the simplest technology has no singular, stable essence, but can be taken up for different purposes or 'stabilities' in different contexts. This idea mirrors Gibson's notion that any object affords a multitude of actions. A pencil, for instance, is typically or canonically (Costall, 2012) used for writing, but can also be used for backscratching or even for stabbing someone. There is no 'essential' use of a pencil. As Ihde (1990) puts it: "A technological object, whatever else it is, *becomes* what it 'is' through its uses", (p. 70). The idea of multistability thus acts as an antidote to readings that perceive technologies solely in terms of their intended use, what is also known as the designer fallacy (Ihde, 2008).

Secondly, to explain how certain stabilities take precedence over others, Rosenberger (2009) introduces the concept of a *relational strategy*, which he defines as "the particular configuration of bodily habits, intentions, and conceptions that make it possible for a person to take up a particular stable relation" (p. 176). Learning to write with a pencil not only means learning the alphabet, it also includes learning the tripod grip (holding the pencil with ones thumb and index finger), adopting the right posture, and learning to draw the letters. As any child versed in the art of filling out worksheets knows, mastering this technique takes hard work. Over time, some relational strategies take deeper roots than others, and technologies are mostly encountered in terms of one's dominant strategy: If one usually writes with pencils, a pencil is directly perceived as a writing tool rather than, say, a backscratching device (Rosenberger, 2017a). Finally, the concept of *mediation* designates how technologies shape the human-world relation: Technologies do not afford action possibilities to preexisting subjects with fixed goals, but subtly invite (Verbeek, 2005) and facilitate (Rosenberger, 2014a) certain comportments while inhibiting

and foreclosing others. Returning to our example, it has been shown that using a pencil to take lecture-notes yields better results than using a laptop (Mueller & Oppenheimer, 2014). In a postphenomenological account, this is because the slowness of pencil note-taking invites students to rephrase and condense the presented material, whereas the compositional speed of a laptop invites students to transcribe material verbatim (Aagaard, 2015b). Nothing in the laptop *determines* that it be used for transcription, however, and we must not understand invitations as lodged 'inside' artifacts: Technologies can only be understood in terms of the concrete relations that we have to them. Let us now apply this postphenomenological approach to the domain of educational technology.

The magnetism of educational technologies

In this section, I want to look at the affordances of a ubiquitous educational technology: The laptop.

I will draw on results from my empirical study of educational technology use in a Danish business college (see Aagaard, 2015a, 2017a). When spending time in educational practice, one quickly discovers that the popular image of laptops and other forms of information and communication technology (ICT) as benevolent forces that connect us to the world, break down traditional barriers, and afford 'anytime/anywhere learning' (Wright & Parchoma, 2011) fails to recognize the deeply ambivalent nature of importing such digital technologies into the classroom: Not only do laptops afford so-called 'technologically-enhanced learning', they also afford classroom distraction (Aagaard, 2017a). In other words, just as laptops open up the possibility of bringing the world into the classroom, they also constitute a backdoor through which students may occasionally escape. Acknowledging such multistability helps us avoid the ICT educator's fallacy, which refers to the mistaken assumption that digital devices introduced into the classroom will be taken up for the precise purposes that designers and curriculum developers envision (Rosenberger, 2017b). With multistability thus established, an important question becomes how the relational strategies that students have developed in the course of their everyday lives intertwine with their educational use of these devices.

During interviews, students described being drawn to distraction in ways that bypass their conscious decision-making: They often experience a *habitual distraction* in the form of a prereflective attraction towards certain frequently visited, but educationally irrelevant websites like Facebook (the following is based on Aagaard, 2015a). Due to deeply sedimented relational strategies that have been built, maintained, and solidified in the course of their everyday lives, the action of logging onto Facebook has become embodied in students' hands and fingers and now occurs habitually. "It's just F, A, and Enter", as the student Karen said. Succumbing to this habitual distraction is deceptively easy, since it occurs independently of students' conscious willpower. Jacob put it like this: "You're looking out of the window and going, 'Oh, it's raining', and then you look back, and now you're on Facebook. If you stop listening for *one* second, you're already on Facebook". This, of course, does not mean that digital distraction is *never* a conscious choice, but deliberate use of Facebook is limited to visits that involve a specific purpose. "If I'm there thinking that I'm going to go on Facebook, that's because I just have

to write to someone or make an appointment", said Dan. "Otherwise, it's a habit". To resist this solicitation and obstruct the habitual slide into distraction, students described occasionally closing the lids of their laptops.

> Jesper: Why can't you just refrain from looking at it?

> Carol: Well it's standing right in front of me, and then you might look down for a second and you're just caught by Facebook. Then you sort of forget the other thing you're supposed to focus on.

> Jesper: So unless you physically shut down the screen, it's simply too tempting?

> Carol: Yes, it is for me. Maybe not for everybody.

Although relational strategies spring from purpose- and meaningful activity, prolonged sedimentation thus seem to make them manifest with a degree of automaticity and stubbornness that challenges our conventional, humanist conceptions of agency and intentionality: Sometimes our habitual use of technologies inclines us do things *we do not intend to do.* Discussing distracted driving, Rosenberger (2014b) similarly notes that: "Like the way those who habitually bite their nails will be on occasion surprised to look down and find they are once again biting their nails, drivers may slide inadvertently and unconsciously into the distracting habits of the phone" (p. 43). The phenomenon of distraction obviously predates the advent of laptops in the classroom, but the idea of magnetic affordances or 'invitations' suggests that digital distraction may differ from existing forms of unmediated distraction like staring blankly into space, since laptops actively shape the relation between students and their classrooms: "When a lesson is experienced as boring, this may to a certain extent be *because* technological alternatives are constantly available and ready to be utilized at a whim" (Aagaard, 2015a, p. 95). This point raises important questions about the role of technology in the classroom (for an in-depth discussion of this issue, see Aagaard, 2017b).

Conclusion

In this article, I have tried to read James J. Gibson's concept of affordances through a phenomenological lens. The benefit of this theoretical reinterpretation is threefold: First, by insisting that affordances actively invite certain actions, phenomenology dispels the awkward idea of 'affordance-facts' that has lead educational researchers to compile strangely detached lists of technical features. Secondly, phenomenology helps us analyze expressly multistable objects like digital technologies that have no canonical affordances (Costall, 2012). As Cutting (1982) argues, a sheet of paper, another quintessentially multistable artifact, affords an endless amount of action possibilities including writing, drawing, wadding up, cutting, photocopying, burning, and so on. "To be sure, it does not afford flying to Baghdad upon", he continues, "but the exclusion of a large domain of behaviors does not diminish the fact that an infinity remain" (p. 216). But does that mean is it up to us to *decide* which of these affordances are utilized? By focusing on our habitualized use of technological artifacts, phenomenology helps us circumvent such potential voluntarism. Finally, granting analytical priority to habits

belies phenomenology's roots in the mundane aspects of everyday life. In the field of educational technology, this self-conscious immersion in routine and repetition guarantees a much-needed fidelity to the 'state-of-the-actual' (Selwyn, 2010), to what is *actually* going in the day-to-day realities of educational practice. In other words, while the laptop surely provides a wealth of technical 'action possibilities', decontextualized analyses that treat affordances as quasi-objectivist features of the world cannot tell us *which* of these affordances will be utilized in practice or *how*. To do so, we must understand affordances as magnetic and multistable. Ultimately, a phenomenological approach to affordances help us do so and thereby provides a critical and empirically based approach to educational technology, which counterbalances the currently reigning techno-optimism ("technologies will save our educational system") without lapsing into technological instrumentalism ("technologies will be what we make of them"). This tactic not only suggests that we place less faith (and money) in the idea of ICT as some sort of educational panacea; it also urges us to discuss the downsides and drawbacks of our current technohabits.

Endnotes

[1]Oliver (2005) ultimately suggests analyzing technologies as *texts*, but I have difficulties discerning this approach from plain affordance-analyses: In an analysis of the virtual world *Second Life*, Oliver (2013) attributes to a red rug on a green field the affordance of 'visible demarcation' between inside (speaking) and outside (listening) positions for student avatars. In a corresponding textual analysis, he concludes: "Having taken away the physical structures usually associated with formal education (the spatial demarcation of conventional institutions) some students were not sure how they should react [...] This led to problems, which the rug was created to address" (p. 40).

[2]Elsewhere, Dreyfus (1991) distinguishes actions that are *logically* and *physically* possible from the smaller subset of actions that are *existentially* possible in a specific situation – one's so-called "live options" (p. 190). This Heideggerian distinction supplements the Merleau-Pontyian contrast between affordance-facts and solicitations that is being made here.

[3]Withagen, de Poel, Araújo, and Pepping (2012) also argue that affordances can invite behavior, but insist that their argument differs from phenomenology, since affordances do not generally invite behavior. In a later article, however, the authors seem to have warmed to phenomenology and insist that, "an ecological account of agency should do justice to this phenomenological insight – affordances are not mere possibilities for action but generally invite us" (Withagen, Araújo, & de Poel, 2017, p. 16).

Publisher's Note

References

Antonenko, P., Dawson, K., & Sahay, S. (2017). A Freamework for Algning needs, abilities and affordances to inform design and practice of educational technologies. *British Journal of Educational Technology, vol., 48*(4), 916–927.

Aagaard, J. (2015a). Drawn to Distraction: A Qualitative Study of Off-Task Use of Educational Technology. *Computers & Education, vol. 87*, 90–97.

Aagaard, J. (2015b). Media Multitasking, Attention, and Distraction: A Critical Discussion. *Phenomenology and the Cognitive Sciences, vol. 14*(4), 885–896.

Aagaard, J. (2017a). Breaking Down Barriers: The Ambivalent Nature of Technologies in the Classroom. *New Media & Society, vol. 19*(7), 1127–1153.

Aagaard, J. (2017b). *Digital Distraction: A Qualitative Exploration of Media Multitasking*. PhD Dissertation. Aarhus: Aarhus University

Bower, M. (2008). Affordance analysis–matching learning tasks with learning technologies. *Educational Media International, vol., 45*(1), 3–15.

Bower, M., & Sturman, D. (2015). What are the educational affordances of wearable technologies? *Computers & Education, vol., 88*, 343–353.

Conole, G., & Dyke, M. (2004). What are the affordances of information and communication technologies? *Research in Learning Technology, 12*(2), 113–124.

Costall, A. (2012). Canonical affordances in context. *AVANT: Trends in Interdisciplinary Studies, 3*(2), 85–93.

Cutting, J. (1982). Two ecological perspectives: Gibson vs. Shaw and Turvey. *The American Journal of Psychology, 95*(2), 199–222.

Dalgarno, B., & Lee, M. (2010). What are the learning affordances of 3-D virtual environments? *British Journal of Educational Technology, 41*(1), 10–32.

Derry, J. (2007). Epistemology and conceptual resources for the development of learning technologies. *Journal of Computer Assisted Learning, 23*(6), 503–510.

Dreyfus, H. (1991). *Being-in-the-world: A commentary on Heidegger's being and time, division I*. Cambridge: MIT Press.

Dreyfus, H. (2007). The return of the myth of the mental. *Inquiry, 50*(4), 352–365.

Dreyfus, H. (2014). *Skillful coping: Essays on the phenomenology of everyday perception*. Oxford: Oxford University Press.

Dreyfus, H., & Kelly, S. D. (2007). Heterophenomenology: Heavy-handed sleight-of-hand. *Phenomenology and the Cognitive Sciences, 6*(1–2), 45–55.

Dreyfus, H., & Taylor, C. (2016). *Retrieving realism*. Cambridge: Harvard University Press.

Gibson, J. J. (2015). *The ecological approach to visual perception: Classic edition*. New York: Psychology Press.

Gibson, J. J., & Gibson, E. (1955). Perceptual learning: Differentiation or enrichment? *Psychological Review, 62*(1), 32–41.

Hammond, M. (2010). What is an affordance and can it help us understand the use of ICT in education? *Education and Information Technologies, 15*(3), 205–217.

Ihde, D. (1990). *Technology and the Lifeworld: From garden to earth*. Indianapolis: Indiana University Press.

Ihde, D. (2008). *Ironic Technics*. New York: Automatic Press/VIP.

Ihde, D. (2009). *Postphenomenology and Technoscience: The Peking University lectures*. Albany: SUNY Press.

Ihde, D. (2015). Foreword: Is there a bat problem for Postphenomenology? In J. K. Friis, & R. Crease (Eds.), *Technoscience and Postphenomenology: The Manhattan papers*. Lanham: Lexington Books.

Latour, B. (2004). How to talk about the body? The normative dimension of science studies. *Body and Society, 10*(2–3), 205–229.

Merleau-Ponty, M. (2002). *Phenomenology of perception*. London: Routledge Classics.

Mueller, P., & Oppenheimer, D. (2014). The pen is mightier than the keyboard: Advantages of longhand over laptop note taking. *Psychological Science, 25*(6), 1159–1168.

Oliver, M. (2005). The problem with affordance. *E-Learning and Digital Media, 2*(4), 402–413.

Oliver, M. (2013). Learning technology: Theorising the tools we study. *British Journal of Educational Technology, 44*(1), 31–43.

Rosenberger, R. (2009). The sudden experience of the computer. *AI & SOCIETY, 24*(2), 173–180.

Rosenberger, R. (2014a). Multistability and the Agency of Mundane Artifacts: From speed bumps to Subway benches. *Human Studies, 37*(3), 369–392.

Rosenberger, R. (2014b). The phenomenological case for stricter regulation of cell phones and driving. *Techné, 18*(1/2), 20–47.

Rosenberger, R. (2016). Notes on a nonfoundational phenomenology of technology. *Foundations of Science*. Advance online publication. https://doi.org/10.1007/s10699-015-9480-5.

Rosenberger, R. (2017a). On the everyday hermeneutics of things: Or, the philosophy of fire hydrants. *AI & SOCIETY, 32*(2), 233–241.

Rosenberger, R. (2017b). The ICT Educator's fallacy. *Foundations of Science, 22*(2), 395–399.

Scharff, R. (2012). Ihde's Postphenomenological Heidegger. *Continental Philosophy Review, 45*(2), 297–306.

Schear, J. (2013). *Mind, reason, and being-in-the-world: The McDowell-Dreyfus debate*. London: Routledge.

Selwyn, N. (2010). Looking beyond learning: Notes towards the critical study of educational technology. *Journal of Computer Assisted Learning, 26*(1), 65–73.

Song, Y. (2011). What are the affordances and constraints of handheld devices for learning in higher education. *British Journal of Educational Technology, 42*(6), E163–E166.

Verbeek, P. P. (2005). *What things do: Philosophical reflections on technology, agency, and design*. Penn State: Penn State University Press.

Withagen, R., Araújo, D., & de Poel, H. (2017). Inviting affordances and agency. *New Ideas in Psychology*, *45*, 11–18.

Withagen, R., de Poel, H., Araújo, D., & Pepping, G. J. (2012). Affordances can invite behavior: Reconsidering the relationship between affordances and agency. *New Ideas in Psychology*, *30*(2), 250–258.

Wright, S., & Parchoma, G. (2011). Technologies for Learning? An actor-network theory critique of 'affordances' in research on mobile learning. *Research in Learning Technology*, *19*(3), 247–258.