Commentary on François Osiurak and Emanuelle Reynaud's "The Elephant in the Room: What Matters Cognitively in Cumulative Technological Culture" (2019)

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In an article published in *Behavioral and Brain Sciences*, François Osiurak and Emanuelle Reynaud (2019) have proposed a new framework to understand cumulative technological culture (CTC). They define CTC as an increase in the efficiency and complexity of tools and techniques in human populations over generations (e.g., Boyd et al., 2011; Richerson & Boyd, 2008), which distinguishes humans from other species.[1] Two concepts seem to be central to explain CTC (Legare & Nielsen, 2015): imitation and innovation. According to Osiurak and Reynaud, previous researchers (e.g., Dean et al., 2012; Lewis & Laland, 2012; Tennie et al., 2009; Tomasello et al., 2005) have mainly focused their attention on the former to explain CTC. Although the authors do not deny the importance of imitation, which is necessary to pass on the *content* of technical information, they champion the idea that CTC originates in non-social cognitive skills instead of in social cognitive skills. They argue that CTC emerges uniquely because a non-social *cognitive structure* (i.e., technical reasoning[2]) enables humans to acquire and develop the *content*.

In this article I will not argue against this hypothesis; instead I will focus on two points that draw on memory expertise. The first one concerns the distinction between *cognitive structure* and *content* on which the authors base their argumentation. The second point is related to humans' unique capacity to imitate a combination of interdependent mechanical actions,[3] which is explained by Wynn and Coolidge (2007) through an enhancement of working memory (WM).

My first point is related to the knowledge principle (Guida & Campitelli, 2019), which states that individuals always use knowledge to process and remember information; in fact we cannot *not* use knowledge. We constantly use knowledge structures to interact with the world. In the domain of expertise, knowledge structures have been highly theorized in terms of chunks (e.g., Chase & Simon, 1973; De Groot, 1946/1978), retrieval structure (Chase & Ericsson, 1982; Ericsson & Kintsch, 1995) or templates (Gobet & Simon, 1996) for example. Applied to Osiurak and Reynaud's framework, it means that there is a recursion between *content* and *cognitive structure*, once a new content is learned, it will change the structure, which will help in the acquisition of new content, and so on. This highly interactive process between *content* and *cognitive structure* is so extreme that our (mental) *content* becomes our *cognitive structure*. Knowledge structures such as chunks, retrieval structures, or templates are first *contents* that we store.

Eventually, however, they become *cognitive structures*, which enable us to interact with the world and efficiently store new *content* that becomes *cognitive structure*. The fact that these two entities are difficult to disentangle is not new (e.g., De Groot, 1946/1978), and computational models such as EPAM-IV

(Richman et al., 1995) and CHREST (e.g., Gobet & Simon, 2000) are based on a discrimination network where information from a new *content* can be incorporated within the discrimination network expanding it via the creation of new nodes (*cognitive structure*).[4] The development of knowledge structures has profound changes in terms of brain structural plasticity (e.g., Maguire et al., 2000; for a review see Zatorre et al., 2012) and functional plasticity (e.g., Bilalić et al., 2016; for a review see Buschkuehl et al., 2012) especially when it comes to templates or retrieval structures (Guida et al., 2012). Concerning the latter, studies on the Spatial Positional Association Response Codes effect (Guida et al., 2018; van Dijck & Fias, 2011) have shown that once individuals know how to read/write—through an increase of their knowledge of written language (*content*)—they will be able to use their knowledge as a retrieval structure (*cognitive structure*) to store information, organizing it according to their reading/writing system direction.

Going back to Osiurak and Reynaud's argumentation, it means that although technical reasoning is the necessary *cognitive structure* to acquire and develop new *content*, the elements that compose technical reasoning were certainly acquired as *content* before being used as a *cognitive structure*. I think that the authors' distinction is too clear-cut, as *cognitive structure* and *content* are related in a recursive fashion. There is a specific point in the manuscript where this is more patent, which brings me to the second point.

Osiurak and Reynaud explain that imitation in nonhumans generally concerns one mechanical action or a sequence of independent mechanical actions but not a combination of interdependent mechanical actions ("combined mechanical actions" from here). The latter would be crucial to account for humans' superiority in terms of CTC. But this explanation begs the question, where does the ability of humans to acquire combined mechanical actions come from? One explanation analyzed by the authors is based on Wynn and Coolidge's (2007) proposal: Our ability would come from an enhancement in WM. However, Osiurak and Reynaud rebut this explanation because WM only stores information and cannot generate content.[5]

I do not agree with their view that considers WM just as a storage facility, which is reminiscent of the von Neumann architecture (von Neumann, 1945) applied to the mind. I believe that three points are crucial. First, WM enable us not only to temporarily store information but also to manipulate it (Baddeley, 2003; Baddeley & Hitch, 1974). Second, recent models (Barrouillet et al., 2004; Cowan, 2012; Oberauer, 2002) envisage WM as the activated portion of long-term memory (although this could be considered controversial[6]), which has, for consequence, that we cannot think about something we do not know, we can only think with our knowledge (see above the knowledge principle). Third, our mental capacity to store information and manipulate it, as measured by a WM span, is highly dependent on knowledge structures such as chunks.[7] The authors are aware of the chunking theory (Chase & Simon, 1973) or the long-term working memory theory (Ericsson & Kintsch, 1995) but seem to disconnect them from the concept of WM. Modern views of WM see it as a combination of processes (Cowan, 2012; Postle, 2006), which should encompass chunking or even retrieval structures.[8] Based on these elements, I believe that the authors should not depict WM just as an empty *cognitive structure*.

In conclusion, while I welcome this new framework of François Osiurak and Emanuelle Reynaud, I hope they can enrich it by relating it to a more interactive view of the concepts of "*content*" and "*cognitive structure*." After all, sometimes the elephant is in the details.

Endnotes

1. Human cultural transmission is described by a "ratchet effect" (Tomasello, 1999): Once an improvement is made, backward slippage is rare.
2. It is noteworthy that Osiurak and Reynaud propose that technical reasoning is also crucial for imitation as it allows to extract relevant technical information from a social demonstration.

3. For example, consider the making of a simple spear: A flake tool is produced in order to cut down a tree and carve from it a spear (i.e., tool-object interaction).
4. Gobet et al. (2018) write: "EPAM [and CHREST] stores information using a discrimination network…Learning consists of creating new nodes (discrimination) and elaborating existing nodes (familiarization).
5. Osiurak and Reynaud write (2019, p. 23): "Working memory is not a cognitive mechanism that is used to generate content, but instead temporarily stores content that is processed by other cognitive mechanisms."
6. Baddeley's model (Baddeley, 2003; Baddeley & Hitch, 1974) does not consider WM as the active part of long-term memory and is the most widespread WM model.
7. When considering chunks in laypersons, WM span can pass from 3 to 7 as modelized by Mathy and Feldman (2012).
8. The theory of long-term working memory is, after all, a WM theory.

Author's Declaration

The author declares that there are no personal or financial conflicts of interest regarding the research in this article.

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