Taking the Historian's Stance in a Natural Science

Zsuzsa Káldy

1 Introduction

As a scientist, I have tried to strike a balance between aiming to be on the empirical "cutting edge" and thinking about big questions that have occupied cognitive scientists for a long time. Most of our published research projects have been the usual kind: continuing the scientific conversation with my peers about topics that we currently find interesting and care about, with some considerations toward the broader context, such as implications for neurodevelopmental disorders or educational practices. But every once in a while, we hit upon an idea where the circularity of history is more apparent. While these projects may not be the ones that get the most citations, they are the ones that I am the most proud of. I believe one of the main ways Csaba has shaped his mentees' thinking as a scientist was by teaching us to 'take the historian's stance'. He showed us the history of psychology as an ongoing, asynchronous conversation, and that our best ideas in the present were very likely have been thought of—in some shape or form—in the past. I will review three of our own research projects that have been directly shaped by the historian's stance. The first one was on iconic memory, the second one was on verbal memory, and the third on mental effort. In the next section, I'll describe each of these in turn.

Z. Káldy (✉)
University of Massachusetts Boston, Boston, MA, USA
e-mail: Zsuzsa.Kaldy@umb.edu

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2 How Can We Measure the Capacity of Iconic (Very Short-Term) Memory in Infants?

Sixty years ago now, George Sperling published his doctoral dissertation in a paper titled *The information available in brief visual presentations* (Sperling, 1960), that became one of the most cited papers in psychophysics. In this paper he sought an answer to the question: what do we remember from what we see? Even in 1960, this was an old question, dating back at least to the work of James McKeen Cattell and Wilhelm Wundt in the 1880s. Most of these studies found that participants could correctly recall about 4–5 items from a visual array, but that they could all tell that they saw a lot more. Sperling realized that the rest of the items faded during the time participants were reporting what they had remembered. How can one capture memories that fade so quickly?

Sperling's crucial experimental insight was to ask participants for only a *partial report* of what they had seen. If participants could recall a (randomly chosen) subset of the original set, right after the stimuli disappeared, then he could infer that they must have encoded all of the items in the original set. (This is also the logic behind spot checking.) Sperling let participants know which subset to report by giving them a cue. For instance, shown a 3×3 array of numbers, participants could be cued (say, by a specific tone) to report just the top, middle, or bottom row. The crucial manipulation uses a "post-cue", when the cue is given only after the offset of the array; successful recall, then, can only have come from some form of memory. The paper became widely cited as it was one of the first examples where a new stage of information-processing in the mind (i.e., iconic, or very-short-term memory) was identified by a psychophysical experiment.

Erik Blaser was a graduate student of George Sperling in the 1990s, and even though George was not working on iconic memory at that time, Erik gained an appreciation for the elegant power of partial report. In the mid 00's, while he and I were working on questions related to infants' working memory, we realized no one had ever studied the earlier stage of iconic memory in early development. We suspected that similarly to adults, infants' iconic memory might a have a relatively high capacity, storing more than the one- or two-item capacity of immediate-memory systems (Kaldy & Leslie, 2003, 2005; Ross-Sheehy, Oakes, & Luck, 2003). Erik and I spend a lot of time thinking about how to adapt tried-and-true adult psychophysical methods to infants, but this presented a real challenge: How could we ask infants to give a report? And, how could we ask them to give us a *partial* report, focused on an arbitrary, experimenter-defined subset of what they had seen? We needed a non-verbal, non-symbolic post-cue that infants would be willing and able to follow. While this may never be truly equivalent to an explicit, verbal instruction in terms of defining goals for the participant, such compromises are an inherent part of experimenting with babies! Erik's crucial insight was that the *disappearance* of items from the array provides the right cue. It is a salient event that naturally draws attention, and, by definition, occurs after offset of the relevant subset of information. In short, we 'told' infants which items they'd be tested on by having them disappear.

In the experiment, first a large set of differently-colored stars were presented in a circular array for 1 s (see Fig. 1, from Blaser & Kaldy, 2010). Then, a randomly selected pair of two neighboring items (let's say a grey and a blue star) disappeared for 500 ms, then the pair reappeared, but with one of them having changed color (in place of the blue item, now they saw a yellow one). Infants were now facing a so-called change detection task (Luck & Vogel, 1997; Oakes, Baumgartner, Barrett, Messenger, & Luck, 2013; Kaldy & Blaser, 2013), where we relied on their spontaneous novelty preference. If they encoded the original colors of both the grey and the blue stars, they would be more intrigued by the yellow item during the final reappearance phase, since that one is novel, compared to the grey one, which did not change. So we measured looking preferences between these two items during this phase. Crucially, since the subset was chosen randomly, performance for the subset of items reflects encoding of the entire set.

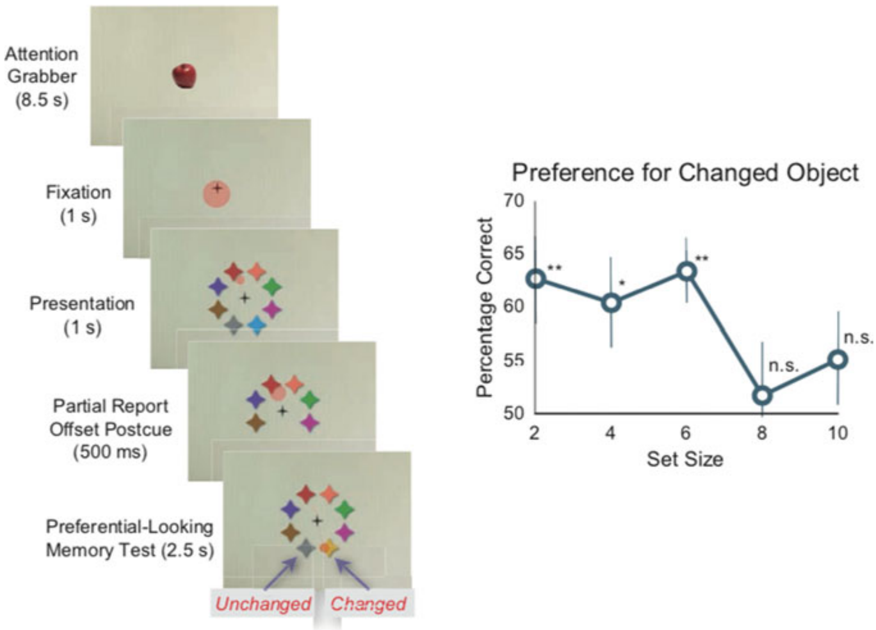

Fig. 1 Measuring infants' iconic memory capacity with partial report: trial sequence and results. *Left panel* trials began with an attention-grabbing animation and a fixation cross. A set of 2, 4, 6, 8, or 10 colored stars was then displayed. The disappearance of two neighboring stars served as the post-cue; when the two stars reappeared after 500 ms, one was changed in color. Memory was tested by preferential looking, and a typical gaze trace from a "correct" trial is illustrated here by the transparent red disk. *Right panel* The graph shows infants' average percentage correct (preference for the novel color) for each set size. Asterisks indicate performance significantly better than chance (*$p < 0.05$, **$p < 0.01$). Blaser, E., & Kaldy, Z. Infants get five stars on iconic memory tests: A partial report test of 6-month-old infants' iconic memory capacity. Psychological Science, 21, 1643–1645. Copyright © 2010 Sage Publishing Co. Doi: 10.1177.09567/97610385358. Reprinted with permission

We found that infants performed above chance with set sizes all the way up to 6, and their level of performance only dropped once we reached 8 items. We also tested adults in the same paradigm, with the same set sizes, but with verbal instructions ("Look at the star that changed color as quickly as you can!"). Adults' absolute performance was, not surprisingly, much better (95–100% vs. 60–63% in infants), but the set size where their performance started to drop-off was also around 6 items. Thus, we concluded that the capacity of infants' iconic (or very-short-term) memory was actually very similar to adults'.

3 Are Children's Long-Term Memories Always Worse Than Adults'?

The field of memory development is full of evidence that young children's memory, as compared to adults', is smaller in capacity in the short-term (Gathercole, Pickering, Ambridge, & Wearing, 2004), and less reliable and more susceptible to suggestion in the long-term (Loftus & Davies, 1984). This has been shown both in the laboratory and when it comes to remembering events, famously, in the context of eyewitness testimonies. But what about material that children really *want* to commit to memory? Maybe there are certain types of memories where the encoding itself is practiced as a skill, and where children may practice more than adults.

As parents, we were always fascinated when our young kids could beat us in some kind of real-life cognitive challenge. Erik and I had been talking with Ildikó Király about our observation that our preschool-age kids seemed to be able to recall their bedtime stories verbatim, better than we could, even though we were the ones reading them the text and they could only rely on auditory memory. Ildikó suggested that it may be *because* they can't read—and as a cultural anthropologist, she suggested an analogy with traditional oral cultures, where without the option of external memory, members of the community were highly practiced at remembering large amount of text, often verbatim. Ildikó, Erik, and I started reviewing this literature and found fascinating work on children's oral cultures recorded by ethnographers in the 1950's in the United Kingdom (Opie & Opie, 1959), David Rubin's empirical studies with ballad-singers in the 1990s (Rubin, Wallace, & Houston, 1993; Rubin, 1995), and that none other than Plato recorded this very same idea by Socrates: "… this discovery of yours [writing] will create forgetfulness in the learners' souls, because they will not use their memories; they will trust to the external written characters and not remember of themselves" (Plato, 1997).

We hypothesized that the type of material that children are highly practiced at committing to memory is rhyming text, and that they will be better than adults at verbatim recall, independent of motivation and general memory performance. Ildikó, with the help of her student Szilvia Takács, recruited a group of parents with 4-year-old children, who were willing to read a new bedtime story (Aliz Mosonyi's short rhyming poem from the 1970s titled *The Radish-Nosed King*) every night for ten days to their child. On the eleventh day, Szilvia visited the families and tested how well children could recall the story, while they followed the pictures in the book (the text itself was obscured). They could recall more than half of the text correctly. Then, to match the children's experience, without any prior warning, parents were asked to do the same. Many of them could barely comply and only recalled only a small set of words.

We then decided to repeat the study with a new set of families (and relegated this first experiment to a footnote of our eventual publication: Király, Takács, Kaldy, & Blaser, 2017), but now we would give parents an unfair advantage and warn them that they will be tested at the end (while the children, again, had no advance knowledge of the test). We asked the parents not to cheat by reading the text more than once a day. Since parents of small children may be more tired and less motivated to memorize text than an average adult, we also added another adult control group: young college students, who generally spend more of their time learning new material. They listened to an audio recording of the text, while looking at the pictures in the book (the text was again, taped over, to mimic pre-reading children's experience), once a day, for ten days. They were also aware that they would be tested at the end. The results of this study were quite astonishing: the children, despite their disadvantage in instructions, could still beat both groups of adults: they could recall more words correctly (out of the 167 words of the poem, kids recalled 117.4 versus 87.2 for the parents and 70.3 for the young adults) and had a lower number of intrusion and confusion errors, where novel or perturbed words were produced (kids averaged 7.6 of these errors versus 41.6 for parents and 54.9 for young adults). We also tested each group on a nonsense, non-rhyming word list that we had embedded in the poem as a control, and on questions about the gist of the story. There were no differences in performance between the groups in these tasks, meaning any disadvantage of the adults in poem recall was not due to lack of attention or effort.

Figure 2 shows how much better children could recall each word of the poem, compared to the young adult group. We expected that children's recall advantage will show up particularly in the rhyming end segments, and less so in the opening segments, and the heat map supported this prediction. (Interested readers can also find my amateur English translation of the poem in the supplementary materials of our paper.) In sum, 4-year-olds were better at spontaneous verbatim recall of a story than motivated and instructed adults, and this advantage was specific to the format (rhyming verse) of the material. We think this is because young children are members of a preliterate tribe, obliged to exercise the skill of verbatim memorization, with a special focus on rhyming stories and songs. Adults in literate cultures can do this, too, but only if they practice a lot, the way professional actors and singers do.

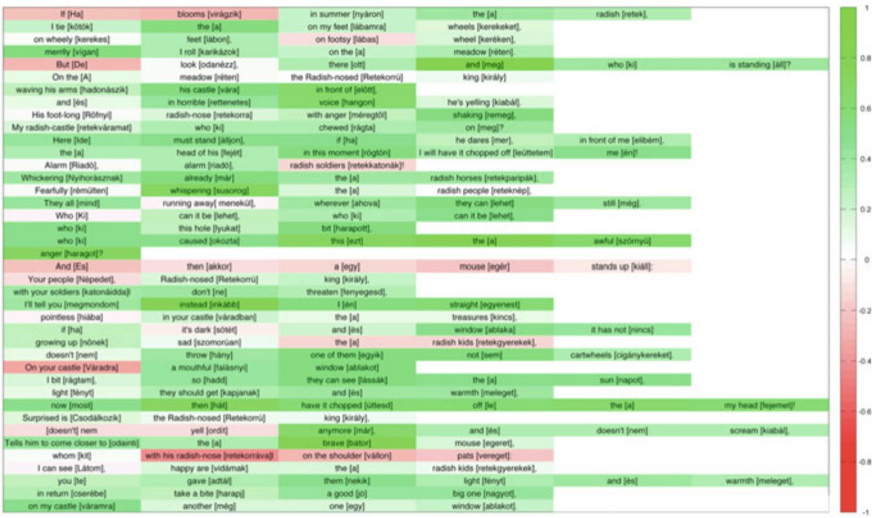

Fig. 2 Heat map contrasting children's performance to that of young adults at free recall of a rhyming poem. Each cell in the heat map shows a word from the poem in Hungarian, with an English translation. The color of the cell reflects the difference in average recall (expressed here as a proportion) for children as compared to young adults. This scale runs from green, 1.0 (children always recalled the word in question correctly and young adults never did) to red, −1.0 (young adults always recalled the word and children never did). Király, I., Takács, S., Kaldy, Z., & Blaser, E. Preschoolers have better long-term memory for rhyming text than adults. Developmental Science, 20, e12398. Copyright © 2017 John Wiley & Sons Ltd. https://doi.org/10.1111/desc.12398. Reprinted with permission

4 Can We Measure How Hard Infants Are Trying to Solve a Task?

Working memory is a workspace for cognitive processes such as learning, reasoning, and decision making, where information is manipulated in support of ongoing tasks. How well working memory works depends, in part, on moment-to-moment *effort*. In adult cognitive research, participants' devotion of maximal task-focused effort is often taken for granted, but in infant studies, researchers have always known that they cannot make that assumption. Most of our methods are based on measuring infants' looking patterns, and when babies are not interested in our experimental stimuli, they look away, try to interact with whoever is around, and if all else fails, "fuss out". Researchers have learned to deal with these clearly visible signs of inattention, and have developed criteria for when to exclude data (Slaughter & Suddendorf, 2007). But we also have to worry about inattention that is not clearly visible. An infant can be looking at our stimuli without trying to actually do what we, the researchers, expect them to be doing: the "blank stares" that Richard Aslin aptly described as "looking without seeing" (Aslin, 2012). In the third study that I will describe, I will show how we tried to tease apart blank stares from effortful scrutiny.

Earlier, we had developed a test of visual working memory, which was essentially a baby-friendly, device-based version of the card game *Memory* (Kaldy, Guillory, & Blaser, 2016, see also Fig. 3a). Two cards Infants were median-up, then turned face-down. Then a third card is turned face-up, that matches one of the previous two cards. As in the original game, the goal was to find the matching card. But, instead of pointing, we used an eye-tracker to see if the infant looked toward the matching card (of the two face-down cards). After giving a two second period for this anticipatory gaze response, we revealed the matching card. We used brief visual rewards on the matching card (such as a fireworks animation) to encourage anticipatory looking. The game was repeated over 12 trials. Older babies could perform decently well in this game, getting 60% of trials correct (as compared to chance, guessing, which would yield 50% correct). But given what we know about babies' mental effort being variable (within and across trials, sessions, and individuals), maybe

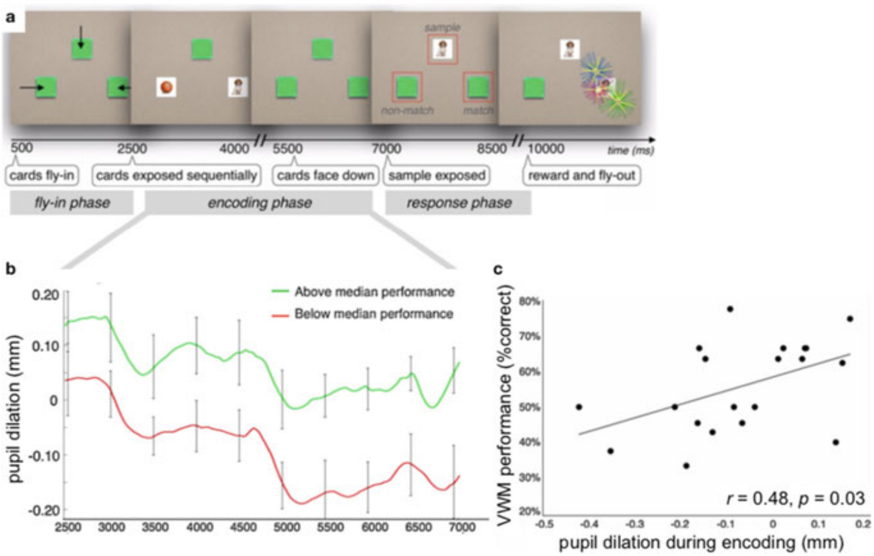

Fig. 3 ***Panel a*****Delayed Match Retrieval paradigm**. First, three face-down cards entered the screen, and then two of them flipped face-up sequentially to show different images (e.g., a ball and a dog), then flipped back face-down. The third card then flipped face-up, which matched one of the two (now face-down) cards. A delay of 3 s then ensued, while eye movements and pupil diameter were monitored. This was followed a brief reward animation at the location of the match card. This was to encourage infants to fixate the (face-down) match, in anticipation of the reward. If infants looked at the match first during the response phase, this was coded as a correct response. ***Panel b*****Pupillometric results (groups)**. Infants were median-split based on their VWM performance. Infants who had overall performed better in the memory task had significantly larger pupil dilation during encoding. ***Panel c*****Pupillometric results (individuals)**. Individual infants' average pupil diameter during encoding/maintenance significantly correlated with their overall VWM performance. Adapted from Cheng, C., Kaldy, Z., & Blaser, E. Focused attention predicts visual working memory performance in 13-month-old infants. Developmental Cognitive Neuroscience, 36, 100,616. Copyright © 2019 The Authors

average performance is a misleading underestimate of working memory abilities. What if we could eliminate the blank stares, and isolate those moments when infants really tried hard—devoting high mental effort—to remember the cards? Given the inherent compromises of developmental paradigms (infants are not told what they are supposed to be doing, nor admonished, or paid, to do their best, as our adults subjects are), this is only fair.

We first started thinking about using pupillometry to measure mental effort around 2012. That was when we came across the groundbreaking work of Silvain Sirois, who showed that pupil dilation signals surprise in violation-of-expectation tasks in babies (Jackson & Sirois, 2009; Sirois & Jackson, 2012, see also Laeng, Sirois, & Gredebäck, 2012). In this work, they relied on an effect that was first demonstrated by Hess and Polt in the early 60s (Hess & Polt, 1960, 1964). In those two *Science* papers, they showed that participant's pupils dilated in emotionally arousing situations (e.g. when looking at photos of naked people) and also when they were asked to think hard (while solving multiplication problems, with harder problems evoking larger pupil dilations). Daniel Kahneman further popularized the method and showed that pupil dilation was a sensitive, moment-to-moment indicator of mental effort in classic tasks such as digit span (Kahneman & Beatty, 1966), and expanded his theory of effort in his book *Attention and effort* (Kahneman, 1973). He later connected this with his dual theory of the mind. System 1 is automatic, quick, and relatively effortless, while System 2 is controlled, slow, and effortful (Kahneman, 2003). The activity of System 2 can be measured by pupil dilation.

In our first study using this method, we found that toddlers diagnosed with autism exerted more mental effort during a classic visual search task (finding a target object hidden among a set of similar looking distractor items) than typically developing toddlers (Blaser, Eglington, Carter, & Kaldy, 2014). This provided a parsimonious explanation for their better performance (Kaldy, Kraper, Carter, & Blaser, 2011). In another pupillometric study, we turned to the infant working memory paradigm I described above. We tested 13-month-olds, but now, along with recording their choice of cards at the end of the trial, we analyzed their pupil dilation during the period of the trial when the to-be-remembered cards were exposed (Cheng, Kaldy, & Blaser, 2019, see Fig. 3). We found that babies who had larger pupil dilation during this period, indicative of greater effort, more often correctly selected the matching card. This relationship was present on a trial-by-trial basis as well: in trials that ended up in correct responses, babies had a larger pupil dilation during encoding. We have also shown that pupil dilation alone can predict performance and looking time is not needed as an additional predictor. In sum, babies' effortful cognitive circuits work very similarly to adults', and pupillometry can also provide a methodological solution to the 'blank stare' problem (Kaldy & Blaser, 2020).

5 Conclusion: What History Can Teach Us

In short, taking the historian's stance keeps us humble. It means that when we think of a new idea, that we trace back the forking paths of references as far back as that idea can be traced back (a task that is now immensely easier than it ever was). Seeing the evolution of an idea or a theory in historical time can give us an understanding that we cannot achieve in any other way. As well, paraphrasing the well-worn quote from Newton that became the tagline of Google Scholar, it allows us the choice of standing on the shoulders of giants, not dwarfs.

Appendix: How Csaba Pléh Instilled the Historian's Stance in Us

I was admitted to Eötvös Loránd University (ELTE) in 1992 and graduated with my Master's degree with Csaba as my thesis advisor in 1998. I could not be there at the graduation ceremony because by then I was a doctoral student at Rutgers University in the US. I spent the next five years there and, after defending my doctoral dissertation, I moved to the University of Massachusetts Boston, where I have been ever since. I set up my lab and together with my husband and closest collaborator, Erik Blaser, have pursued a research program studying infants' and young children's visual attention and working memory. I have been the proud mentor of more than a hundred psychology students in the past twenty years. I, along with many of the contributors of this volume, can say with absolute certainty that I would not be where I am without Csaba's mentoring during those years in the mid-90s.

In the early nineties, Hungary was quickly transforming from "the happiest barrack" of the Communist countries to a fledgling democracy. In 1992, we were the first cohort at ELTE that had complete freedom to choose their classes in the new "credit system", and we saw the "specializations" (the rough equivalents of Master's programs) forming just a year or so before we were about to take them. In our brand new "cognitive specialization', we took seminars on cognitive science led by Csaba, and also by his most recently graduated mentees: Szabolcs Kiss, Miklós Győri, and Zoltán Jakab. My peer group of friends at ELTE, Ágnes Lukács, Mihály Racsmány, Ildikó Király, Anett Ragó, Levente Juhász, Krisztina Egyed, Attila Krajcsi, Dezső Németh became the next wave of young Hungarian cognitive psychologists who are today in key academic positions. But back in the early 90s, when we were sitting in those fluorescent-lit seminar rooms on Izabella Street, this was still in the future. We read the latest books on cognitive science—not the ones students bought in their campus bookstores in the US, but xeroxed and spiral-bound copies. When we wanted to find journal articles in English, we went to the library and checked out CD's that contained all the papers indexed in PsycInfo up to a certain date—and about half of the time, we could find the papers we were looking for.

In 1994, I was lucky enough to get into a unique mentorship program called the Invisible College. The Invisible College, financed by a Hungarian bank, and later by George Soros's foundation, employed a group of leading academics to provide small-group teaching and one-on-one mentoring to a small group of college students in the liberal arts, economics, and law. Beyond simply giving additional education in a student's chosen field, the goal was to establish links between young people across these disciplines. Whether the program achieved that goal, I cannot tell, but it gave me the opportunity to become Csaba's mentee.

In terms of Csaba's timeline, it was around this time that he had just returned from a year at University of Indiana Bloomington, in 1992, and then left to spend the 1996/97 year as a Fellow at the Stanford Center for Advanced Studies in the Behavioral Sciences. His major opus, *The History of Psychology* (at that point, in its first, Hungarian edition) was on all of our bookshelves and we listened to his lectures on the influences of Popper, Brentano, and Wittgenstein on current psychological theories. He showed us how those ideas emerged and re-emerged in the theories of the late twentieth century: in connectionism, in the ideas of Karmiloff-Smith, Dawkins, Fodor, and many others, and in the writings of one of Csaba's favorite intellectual heroes, Daniel Dennett. *The Intentional Stance* was published in 1987. In it, Dennett describes three potential interpretative frameworks that humans can use to predict what a certain object or agent is going to do, a *physical*, a *design*, or an *intentional* stance (Dennett, 1987). When we try to predict the next move of a chess program, we could look at the processor in the device (taking a physical stance), read the code of the program (a design stance), or imagine that it has the *goal* of beating us (an intentional stance), and that it will pick moves that make the most sense to reach that goal. Taking the intentional stance allows us, the opponent, to make the best possible prediction, and not just with chess programs, but our fellow humans as well, and Dennett argued that this is why this mental tool evolved. Here, I frivolously co-opted his term and claimed that Csaba has taught us to take the *historian's stance* to the study of psychology, and that taking this stance leads us to the best scientific questions.

For young scientists, learning the history of psychology can be daunting, as even a cursory look at the history of ideas leads one to the conclusion that there is nothing new under the sun. The depth and breadth that Csaba's conveyed in his lectures, papers, and books, seen from his mentees' perspective, was, indeed, intimidating, but, at a certain point, it also became motivating. We learned to be humble, yet also saw how science could still be about discovery and expanding knowledge. I started to imagine the progress of science as the sum of two vectors: one circular and another, pointing outward, as you would move along the surface of an ice cream cone, circling back but each time a step further. And as I write this, I know that if I were a proper historian of science, I would investigate to see if someone had come up with this (admittedly, very simplistic) metaphor first. Or I could just ask Csaba!

When I first arrived in the US, I was surprised to find out that most of my graduate student peers had multiple empirical articles published in high-profile journals, but they could not name a single psychologist from before 1970. It took me some time to realize that *not* taking the historian stance is a distinct feature of American science education, related to a general neglect of history in American culture. (Even after this realization, I was still shocked when in 2019 a graduate student in our program said that they were told by their previous mentors not to read anything that was published more than ten years ago!) Young scientists in the US are taught to cite their sources, but this rarely means more than simply making sure that credit is given to colleagues who could be upset about not getting this credit (since citation is a key currency of academic achievement). Teaching students to see themselves as heirs to previous generations of intellectuals does not factor into this exercise.

Concluding Thoughts: How to Foster a Historian's Stance in Psychology Students, Based on How Csaba Did It.

1. *You have to know a lot*

Well, this is clearly the hardest and to get anywhere close to Csaba's level is basically impossible. The best bet is to approach this goal piecemeal. If you need any help finding your sources, just look up any of Csaba's books on your topic.

2. *Introduce historical figures as flesh-and-blood people*

This is much easier. I don't think that students in my introductory developmental psychology lecture will remember much about how early behaviorism shaped our current theories of learning, but they will for sure remember that John Watson was fired from Johns Hopkins University because of his affair with his research assistant. Some of them may even remember that he published his famous Little Albert study with her as co-author and that in his second career as an advertising executive he coined the term 'coffee break' for a Maxwell House ad campaign.

3. *Describe science as an ongoing conversation, including hypothetical Q&A's*

Once you've done #1, then this just requires some imagination! That fancy cognitive mechanism you are contemplating sure sounds exciting, but could Skinner train a pigeon to do that? What would Tinbergen say about the just-so story in the Discussion section of the paper you are reviewing?

4. *Encourage students to read some of the original texts*

As I discovered, this advice sounds extremely weird for American psychology students. Most developmental psychologist researchers in the US would cheerily admit that they have never actually opened a book by Jean Piaget (despite his work still being the core of the material in all introductory textbooks). In my teaching, I try to guide students to at least one or two original works, so that they can get a better sense of the author's thinking, without present-day selections and interpretations; for example, *The psychopathology of everyday life* when I talk about psychodynamic theories (who is not interested in Freud's own Freudian slips?).

Finally, I would like to thank the editors: Judit, Kristóf, (both alumni of Invisible College) and Gergő for the opportunity to share these thoughts. Happy birthday, Csaba!

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