After smartphone : Towards a new digital education artefact

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ABSTRACT

Non-moderate smartphone usage may induce diverse pathological states and behaviors which may potentially result in an array of syndromes and illnesses. Digital devices built for education rather than consumption and entertainment should not neglect intricacies of human physiology, ergonomy and cognition. For this reason, we present first four properties of an idealized "digital primer" artefact which could maximize the human and cultural potential of a normal elementary school pupil by means of holistic, semi-supervised interaction. Properties addressed and defined in this article are: "speech-based", "narrative", "circa-temporal" and "habit-disrupting".

KEYWORDS: DIGITAL PRIMER, SPEECH-BASED, CIRCA-TEMPORAL, NARRATIVE, HABIT-DISRUPTING, SMARTPHONE EPIDEMIC.

RÉSUMÉ

Après le smartphone : vers un nouvel artefact numérique pour l'éducation

L'utilisation immodérée d'un smartphone peut entraîner des syndromes, comportements pathologiques, voire des maladies. Les appareils numériques conçus pour l'éducation plutôt que pour la consommation et le divertissement ne doivent pas négliger les subtilités de la physiologie, l'ergonomie et de la cognition humaine. Pour cette raison, nous présentons les quatre propriétés principales d'un artefact idéalisé appelé « abécédaire numérique » qui pourrait maximiser le potentiel humain et culturel d'un élève du primaire par le biais d'une interaction holistique et semi-supervisée. Les propriétés abordées et définies dans cet article sont les suivantes : « basé sur la parole », « narratif », « circa-temporel » et « perturbant l'habitude ».

MOTS-CLÉS : ABÉCÉDAIRE NUMÉRIQUE, TECHNOLOGIES DE LA PAROLE, LES APPAREILS NARRATIFS ET CIRCA-TEMPORELS, L'ÉPIDEMIE DE SMARTPHONE.

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INTRODUCTION

Do smartphones make us smart?

As is the case for every technology, smartphones can be considered to be good servants but bad masters.

Used with moderation, smartphones facilitate one's access to information and knowledge and augment one's social capital. They bring the planetary knowledge to very tips of one's hands, they allow us to "speak" to most sophisticated Artificial Intelligences ever created.

Yet, when used with excess, smartphones may induce diverse pathological states and behaviours which may potentially result in an array of chronic illnesses. In physiological domain, role of touchscreen-based media in causing deQuevrain's syndrome – known also under synonyms like "texting thumb" or "cellphone thumb" – is well known (Eapen et al., 2014; Karim, 2009) and is not very optimistic. Other studies reveal "relationship between smartphone use and musculoskeletal discomfort" (Yang et al., 2017), show that "showed that musculoskeletal problems in neck and hand can be seen in smartphone addicted students which may be short term initially but may later lead to long term disability" (Shah & Sheth, 2018) or even conclude that "smartphones negatively affect cervical posture, as well as respiratory biomechanics among boys and girls" (Alonazi, 2017).

When it comes to psychic, social and cognitive impact of smartphone use, the story is also not as pleasing a bed of roses as advertisement industry depicts it. Non-negligible body of evidence (e.g. Elhai et al., 2016; Wolniewicz et al., 2018) indicates that "depression, anxiety, and sleep quality may be associated with smartphone overuse" (Demirci, Akgönül, & Akpinar, 2015). What's more, a sound and exhaustive experimental study shows that the very presence of one's smartphone within one's visual field brings about reduction of one's cognitive resources (Ward et al., 2017). As smartphone addiction increases both in scale as in intensity, new hitherto unknown disorders like "nomophobia" (King et al., 2014; Tran, 2016), "technostress" (Lee et al., 2014) are more and more frequent, paving the way for such nefarious phenomena as cyberbullying (O'Neill & Dinh, 2015) and smartphone-mediated suicides (Twenge et al., 2018).

All in all, one may even be tempted to state that smartphones are, in fact, not as "smart", "amazing" and "gorgeous" as Steve Jobs used to present them [1].

Towards a new digital education artefact

In spite of the critical stance adopted in the previous section, we align ourselves into the camp of techno-optimists as Khan (Kay, 1972; Khan, 2012; Negro-

[1] Note that Jobs' stance in regards to children's use of smartphones was quite straightforward: "We limit how much technology our kids use at home" (Bilton, 2014)

ponte, 2006). Being techno-optimists, we are strongly convinced that technologies – when designed with wisdom and modesty – can address and resolve many problems. In regards to education, we believe that digital media – when properly deployed – could make the education of human Children more just, engaging and efficient. Paradoxically, it may even be the case that digital media – when designed with certain constraints in mind – could make the teacher-student relation more human than is the case in an average school of our era in which a single teacher is overloaded by a herculean task of steering development of dozens distinct human individuals.

As precised elsewhere (Hromada, 2019b), we define the goal of "digital education" as follows:

The task… is to maximize force of judgment, in-depth knowledge, skillful expertise and personal integrity of voluntarily learning learners by means of well-thought, future- oriented, cognition-enhancing humanist curricula involving education-of-digital or education- with-digital methodologies.

The artefact by means of which we aspire to accomplish this task is called a "Personal Primer".

Personal Primer and its properties

Personal Primer ($\pi 2$) is a digital artefact aiming to enrich narrative, mathematical, musical and naturalist intelligence of an elementary-school pupil. As we see it, Primer is an artefact which instantiates 23 attributes divided into "physical", "cognitive" and "didactive" classes (c.f. Annex 1). In this article, we more closely introduce four "introductory" properties which are being currently embedded into a functioning prototype. These are "speech-based", "narrative", "circadian" and "habit-disrupting".

Speech-based

Speech precedes text both in phylogeny as well as in ontogeny. Non-negligible amount of anthropologic, physiologic, neuroscientific and psycholinguistic evidence suggests that our ability to generate speech is innate and intrinsic component of human genetic heritage. Human brains,

human vocal cords and maybe even human posture and human lungs- they all co-evolved, during hundreds of thousands – or even millions – of years along with social and semiotic systems we now call "language" (Pinker, 2003).

On the other hand, painting, text, or hypertext are relatively recent – i.e few millenia resp. few decades old. In evolutionary and constructionist (Tomasello, 2009) terms, speech offers the foundation in which all later semiotic systems – be it writing, icons, mathematical language formulae etc. – are grounded.

In education, speech is inevitable: no matter whether we speak about oral transfer of know-how in a pre-literal society, a classical frontal lecture in an elementary school or an online course offered by Khan Academy (Khan, 2012), the Teacher's speech is always there, allowing the student to access concepts far beyond the concrete and the tangible.

For this reason, Primer is to be speech-based:

Definition: An artefact is **speech-based** if it is able to:

1. recognize and "understand" human speech
2. generate and "speak" human speech without any recourse to external system.

As of 2018, certain products which combine speech recognition and speech synthesis technologies exist: Siri, Alexa, MyCroft etc. But since majority of these systems does not implement an offline, embedded speech recognition engine but rather exploits a centralized cloud-based speech recognition system, these do not qualify as speech-based digital artefacts in sense of the above-mentioned definition.

What's worse, it can be anticipated that the usage of centralized, monolithic speech recognition systems can lead to acceleration of decrease of diversity of languages and local dialects. This danger is considered to be evermore relevant if one considers the implementation of such systems in education of human Children. For it can easily happen that instead of a machine adapting itself to a Child, a Child shall adapt itself to a machine.

For this reason, internal "speech models" of the Primer should develop locally, through and by means of interaction with human Children. Ideally, speech faculties of the Primer are to adapt to speech faculties of the Child. The Child shall, in certain sense, teach the artefact her own language, she will become its language teacher. In such a way, the Child is to be put into the position of the Teacher which can turn out to be a motivating moment for the Child.

Narrative

"People are narrative animals" (Mateas & Sengers, 2003) and "knowledge is stories" (Schank, 1995): such are main principles of the narrative turn which spans all sub-disciplines of cognitive science, from anthropology to A.I. And no matter whether one means a fireplace-stories performed by elders of Neolithic societies or bards and poets of antiquity, no matter whether one means myths, legends, fables, fairy-tales, sermons, theatre pieces, enacted biographies or the most recent YouTube videos, narratives have been and shall not cease to be an ultimate vector of didactic transfer.

In case of children, the importance of narrativity seems to be even more marked. For as has been already beautifully demonstrated by Piaget and others, children lack the access to abstract formalisms of mathematics or philosophical terminology. And such terminology and such formalisms are often grounded (Harnad, 1990) in stories. For example, enactment of a semi-mythical story of

an apple falling on Newton's head is a mandatory rite of passage of any teacher or parent aiming to transfer the notion of "gravitational force". What's more, narratives also play a key role in development of moral intelligence (Vitz, 1990). That is, in transfer of concepts (e.g. good, bad, just etc.) and values (e.g. wisdom, courage, freedom) which form the very glue of human societies. And it is worth noting that until fairly recently, such development of moral intelligence – be it by means of morals encoded in Aesop's fables or etiquette primers of Victorian era – has been an indispensable element of education. And given that millions of children are exposed, on a daily basis, to thousands of videos where images of mutilation, lapidation, burying-alive etc. are consider to be "normal" (Bridle, 2018) we consider a playful yet efficient reintroduction of moral concerns into digital and media education to be of certain importance.

For these reasons, Primer is to be narrative:

Definition: An artefact is **narrative** if it is able to

1. expose the learner with vast amount of didactically relevant stories
2. invite the learner to construct and articulate own narratives
3. adapt the content of generated stories to the current context.

It may be observed that the "speech-based" property of the artefact goes hand in hand with the "narrative" property. While the former specifies a sort of a communication channel by means of which a Child-learner can be reached, the latter specifies the content of messages which are to be transferred. Both include a productive component (P-component) as well as a comprehension component (C-component). Speech-to-text and extraction of morally relevant features (Hromada, 2015) yield the C-component; generativity, vector-space architectures and text-to-speech yield the P-component. Similarly to cases of parent-child interaction (Hromada, 2019) subroutines forming the C- and P- components should coevolve: stories generated by the artefact relate, in one way or another, to stories spoken by the Child.

In such a way, an artefact could potentially adapt to the Child, increasing her narrative and moral competence in the process.

Circatemporal

One should not underestimate the importance of rhythms for healthy existence and development of human individuum. Leaving the trivial examples of heart-beat and breathing aside, one can add that something like a tact-giving "internal oscillator" (Fraisse, 1982; Provasi & Bobin-Begue, 2003) plays a non-negligible role in synchronization of different modules of human cognitive system. Looking at longer time-scales, one can see that 24-hour-long "circadian" rhythms play a major role in modulating body's biochemical balance, in concert with a so-called "chronotype" encoded within the DNA of the particular individual (Taillard et al., 2003). And those who focus their attention on larger periods of weeks, months and seasons, may indeed notice that in many traditional human societies – if not in all – a sort of division of bigger time units into

periods of "profane" work and periods of "sacred" celebrations (Durkheim, 1912) seems to be an ubiquitous means of bringing order into society.

Machines, however, seem to be utterly unaware of the "prophane" / "sacred" distinction. In spite of displaying "Saturday" or "Sunday" on their screen, our digital artefacts are ready to do execute the same work for us as they would do on an ordinary day. Cloud never sleeps and servers are "always on" in the globalized-society which spans all time-zones and where perpetual consumption is seen to be the utmost good (Hromada, 2019a). And since servers are always on, client devices are made to be always on as well: no smartphone available on a 2018 market does care about its user's chronotype. Disruption of circadian rhythms and overuse of digital media can easily lead to sleep deprivation. Consequently, basic cognitive faculties like long-term memory consolidation (Gomez, 2011) and learning (Arendt, 2000) can also be negatively affected. Emotional disturbances like depression may emerge as well (Lemola et al., 2015). Hence, an "always on" character of contemporary digital education media often counteract the benefits brought about this media. Even the most worthy didactic app may easily lose its value when applied in cognitively inappropriate way. Even the highest quality content may not deliver an expected result when the brain is unable to absorb it. Or, worse, when the medium itself reduce brain's overall aptitude to absorb.

For these reasons, Primer is to be circatemporal:

Definition: An artefact is **circatemporal** if it is endowed with pre-built internal rhythms.

Given their importance for human well-being, circadianity is the very first among 23 properties listed in Annex 1, which is to be embedded in the Primer prototype. Hence, the Primer will be "a device that exhibits at least one transition (e.g. "deep-sleep to full activity") which takes place within 24-hour period and is triggered not from the software, but rather from the most fundamental hardware layer" (Hromada, 2019a).

For example, the major boot-up time of our current Primer prototype is at 14:30 of the time zone within which it is currently located. Consequently, the Primer is active for an hour, inviting the Child to perform whatever activities she finds appropriate (e.g. reading, writing, speaking, listening, arithmetic etc.). After one hour, the artefact shuts down on its own, in order to wake up once again at 18:00 for a "minor" interaction session lasting 30 minutes. At 18:30, it shuts down and stays deactivated until next afternoon.

Activation and de-activation times can be potentially configured by Primer's adult operator (teacher, parent etc.) and should consider not only child's daily and weekly schedule (e.g. structure of extracurricular activities), and didactic aim, but last and foremost, the chronotype of the specific child with which the Primer is supposed to interact (e.g. in case of some children, afternoon peak is maybe not at 14:30 but at 16:30).

Habit-disrupting

It has been suggested (Hromada, 2009) that – at least in case of human brains – is the probability of a repeated activation of a neural program P_X inversely proportional to time elapsed from last activation of P_X. This implies that all other things being constant, human sensorimotor circuitry will tend to reproduce the behavior just produced. Such "propensity to cognitive inertia", coupled with deliberate effort of major corporations to captivate their consumers with casino techniques based on dopamine release induction (Haynes, 2016), ultimately lead to formation of fairly strong habits.

According to a 2016 study, average user of an Android smartphone haptically interact with his device 2617 times. A heavy smartphone user (top 10% of the measured user pool) executes 5427 daily touches (Winnick, 2016). That's almost a million taps & swipes in a year of an average smartphone user, and more than 2 millions in a year of a heavy user. For comparison: an average participant of a large-scale physical activity study recorded 4,961 steps per day (Althoff et al., 2017).

While it is more or less certain that habits like walking increase one's fitness, it is fairly uncertain that habits like tapping a screen with a finger increase one's fitness as well. As indicated by the introductory section of this article, the contrary situation is more likely to be the case: a decrease of evolutionary fitness may occur there, where simple planar 2d touchscreen interfaces are to be understood as main ways of interaction with complex 3d spaces populated with objects of different volumes, weights, densities, velocities, odors, flavors etc. In order to minimize the danger of such an evolutionary regress in children exposed to it, an ideal Personal Primer is to be habit-disrupting:

Definition: An artefact is **habit-disrupting** if it is able to

1.weaken fitness-reducing habits of the Child

2.establish and strengthen fitness-increasing habits.

In didactic terms, the habit-disruptiveness is to be attained by variation of Primer-generated instructions and meta-instruction, including the meta-meta-instruction: "now solve this problem in a different way!".

In technical terms, the habit-disruptiveness is to be principally attained by implementation of new types of sensors. Not only stereoscopic-vision cameras, but also cheaper ultra-sound seniors and electrode-based, theremin-like slates may allow the Primer to perceive the dimension of depth and with it, Child's actions of "approaching", "going away" etc.

Asides this, the instruments mediating the contact between the child and the Primer may also vary: in theory, we see no reason to force a child to use a boring plastic stylus there, where she could opt for a bird feather or a quartz crystal stick of her own choice or making. And in use-case scenarios where touchscreen seem inevitable, one can still attain a fairly high level of habit-disruptiveness by substituting the Boolean tapping & swiping with a palette of complex multitouch gestures or rhythmic behaviors.

All in all, in cases of artefacts whose "raison d'être" is cognitive enrichment of their users and not increase of interaction speed, we propose to shift interest from numbing, polished-but-boring, everywhere-the-same user experience (UX) to more dynamic, surprising, evolving, co-adapting and cognitively challenging "inconvenient" user experience (UUX).

CONCLUSION

This article presents four initial properties of a humanist digital education artefact called Personal Primer or π^2. These properties are: speech-based, narrative, circatemporal and habit-disrupting. Other 19 properties which we consider as relevant are enumerated in the Annex.

In certain sense, the aims of the π2 project are analogous to aims of the "One Laptop per Child" (OLPC) (Negroponte, 2006) or DynaBook (Kay, 1972) project. Empowerment, confidence and self-confidence, structuration of free thought, development of skills and enhancement of cognition attained by well-thought interaction between the child and the universal Turing machine: these goals are common to both projects.

The paths, however, differ: while OLPC extends the idea of a PC, the π^2 aims to extend the old Gutenbergian idea of "a book".

A book which teaches. A digital artefact which educates. Not a "smart" device whose dopamine-releasing entertainment strategies provably make our children dumb.

Rather, a seemingly dumb digital companion whose questions and stories will make us and our children, gradually and hopefully, wise.

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Annexe: 23 properties of a digital primer

1. **embooked**: looks like a book and has many properties of a book
2. **unique**: every Primer can be different
3. **adaptable**: some parts of the hardware (e.g. the cover) can be created or "gebastelt" by the pupil
4. **modular**: there are multiple modules which can be wired together and pupil is incited to find out for herself which wirings are ok and which not
5. **robust**: can fall, be thrown, stepped upon or be active during different weather conditions
6. **bilateral**: 2 computational cores; 2 cameras (eyes); 2 microphones (ears); 2 screens (e.g. 1 x OLED, 1 x E-ink) symmetrically distributed on both inner sides of the Primer
7. **environment-aware**: awareness of its position in time and space, awareness of surrounding weather, environment, humidity etc.
8. **circadian**: modes of operation differ according to time of day; usage during certain times is penalized; at night, artefact is not operational at all, in the morning, it can helps parents to wake the child up etc.
9. **moody**: artefact has moods which are not completely deterministic and influence how artefact behaves
10. **preferential**: artefact valorizes certain modes of interaction more than others [handwriting preferred than keyboard; long sentences preferred more than short ones etc.]
11. **cooperative**: when requested, primer can help the child to solve a certain problem by (e.g. homework in mathematics) showing how analogic problems are solved
12. **habit-disrupting**: invites the child to discover new means of interaction; penalization of unreflected repetitve behavior
13. **ludic, meta-ludic and funny**: contains games and should allow the child to create new games; contains a joke-database and/or a joke-generation engine
14. **mnemonic**: artefact keeps a "history" of its past interactions with the child
15. **multimodal**: promotes input and output through many communicative modalities
16. **speech-based**: strong emphasis on speech synthesis, speech control and speech recognition
17. **narrative**: default mode presents the study course by means of fairy-tale-like stories
18. **cybertextual and encyclopedic**: every word, picture or expression can serve as gateway to further activity
19. **online-offline**: artefact can go online only at times explicitely authorized by the Teacher
20. **protected**: no communication with the Internet without explicit authorization of the authority (parent or teacher)

21. **script-based and teacher-curated**: teacher can so-called "playbooks" into the primer

22. **eye-to-eye**: facilitates eye-to-eye interaction between student and a teacher

23. **avatarized**: teacher's avatar can be consulted even when the real teacher is not available