

what if the “I” in HCI stands for Integration?

pedro lopes

associate prof. in computer science



evolution of computing interfaces

your device



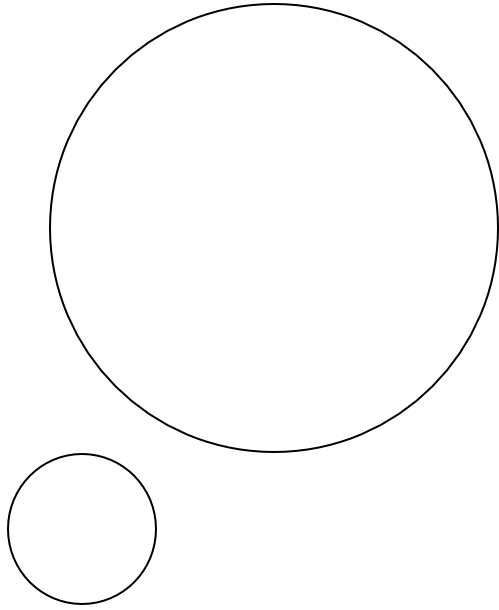
you



mainframe

(computers that took up an entire room)

early computers used command line interfaces (CLI)
to enable expert-users to **perform simulations**

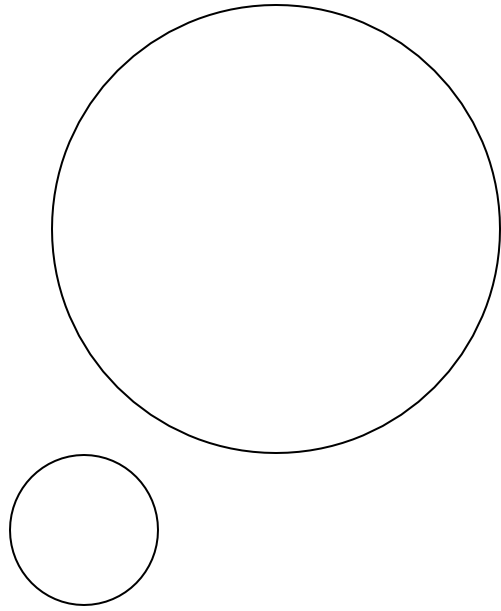


mainframe

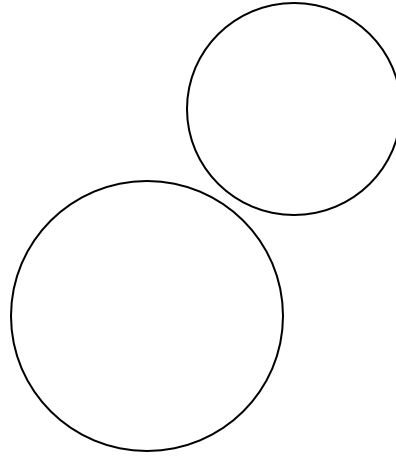


desktop

in the 80s the desktop's graphical user interface (GUI)
moved computers into **millions of offices & homes**



mainframe

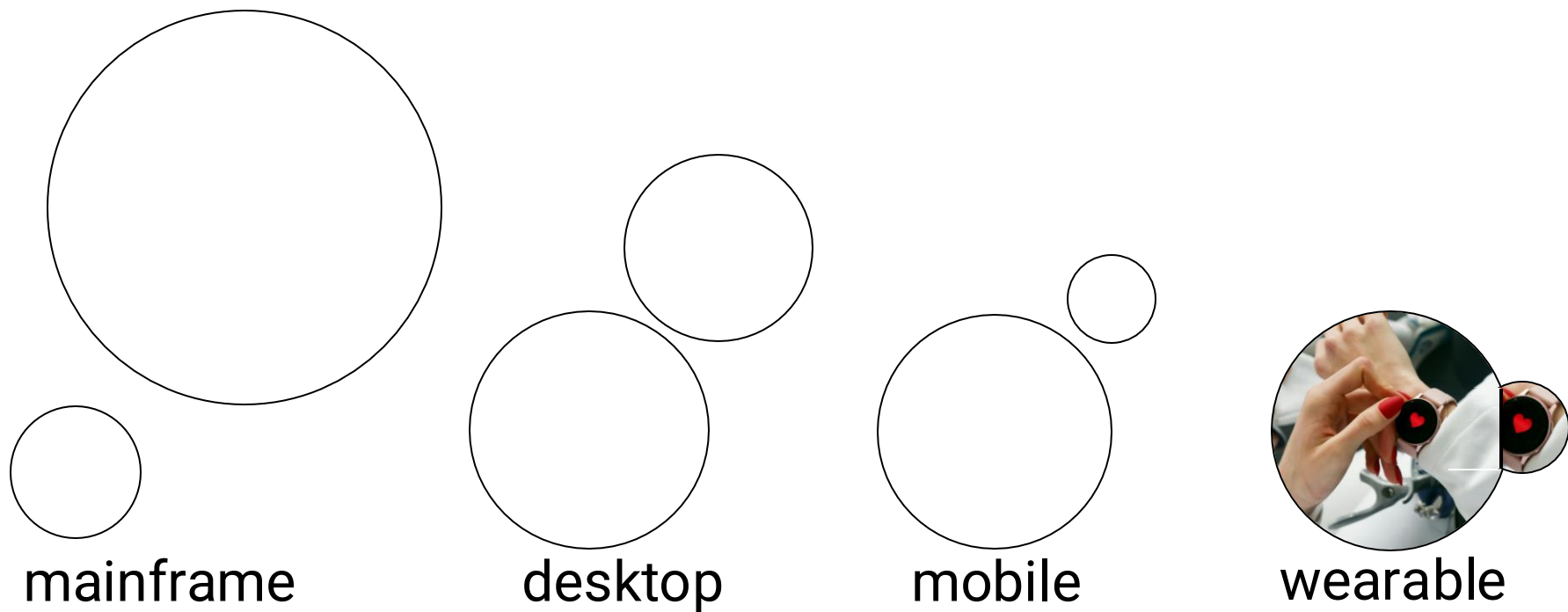


desktop

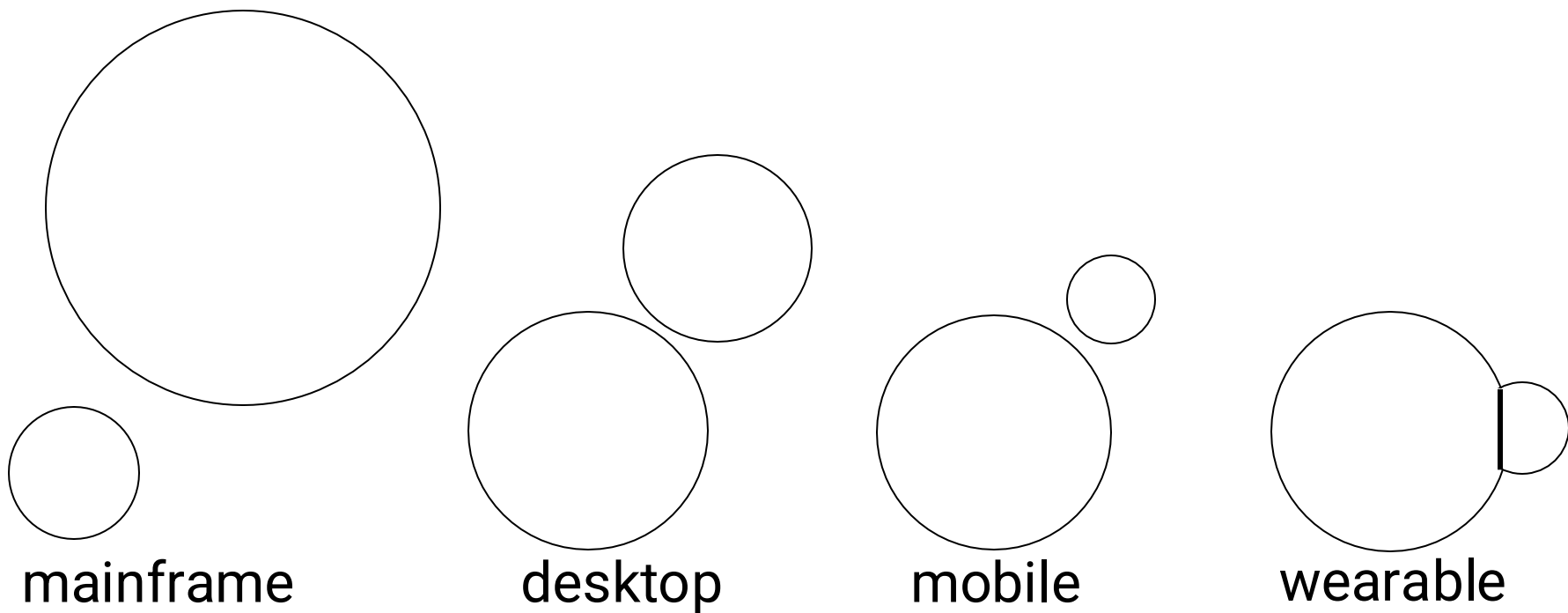


mobile

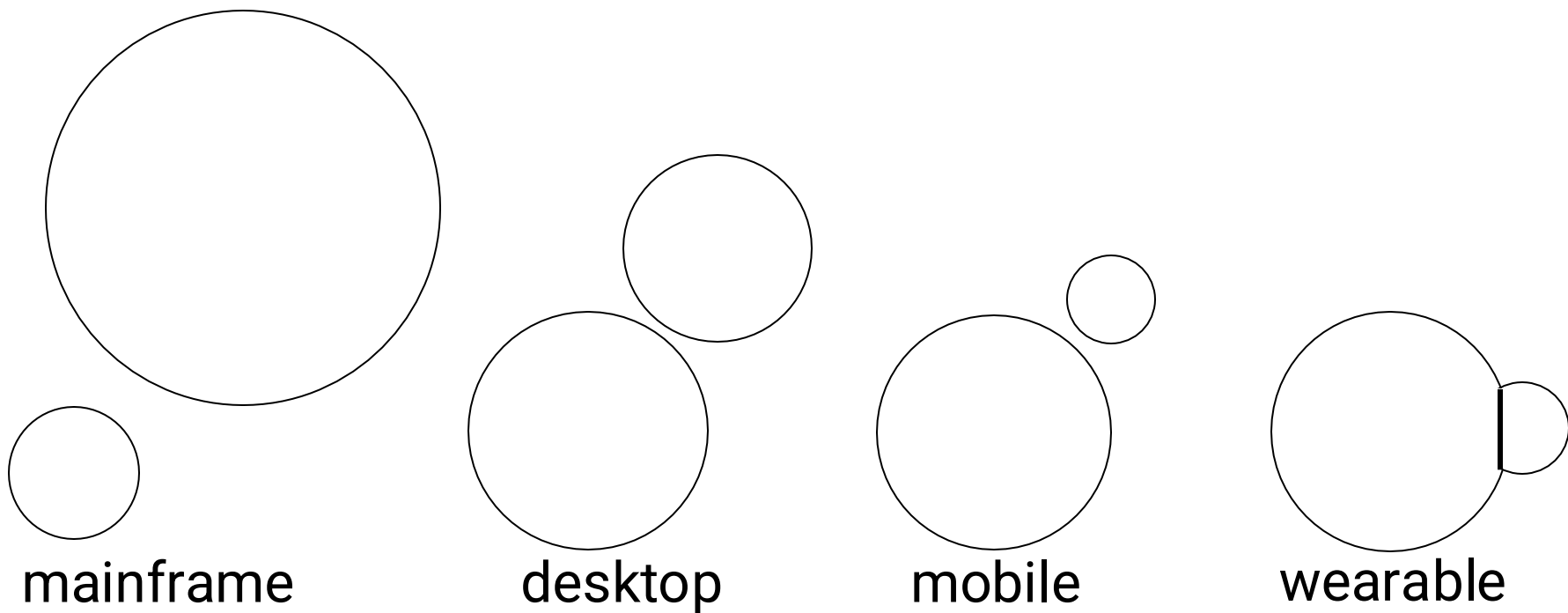
in the 90s, mobile devices moved computing into
billions of pockets, accessible **anytime & anywhere**



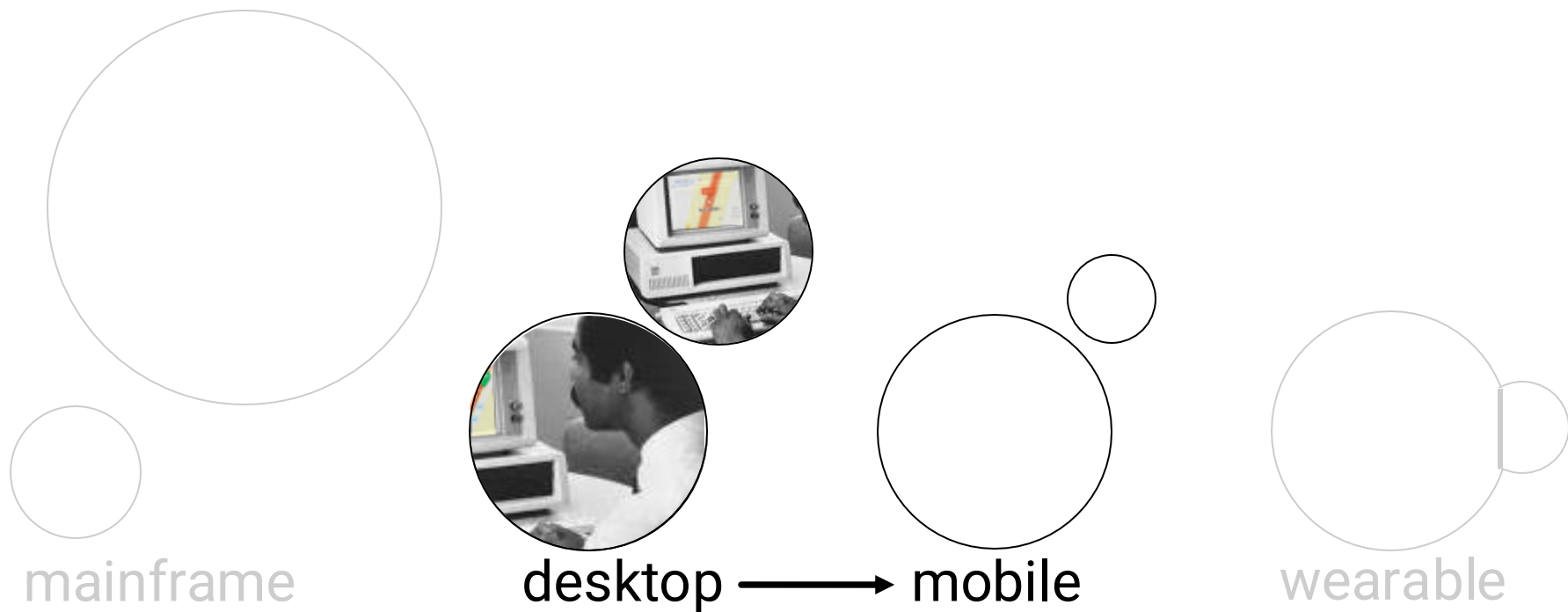
wearables are in **physical contact with the skin**,
enabling sensing users' physiological signals



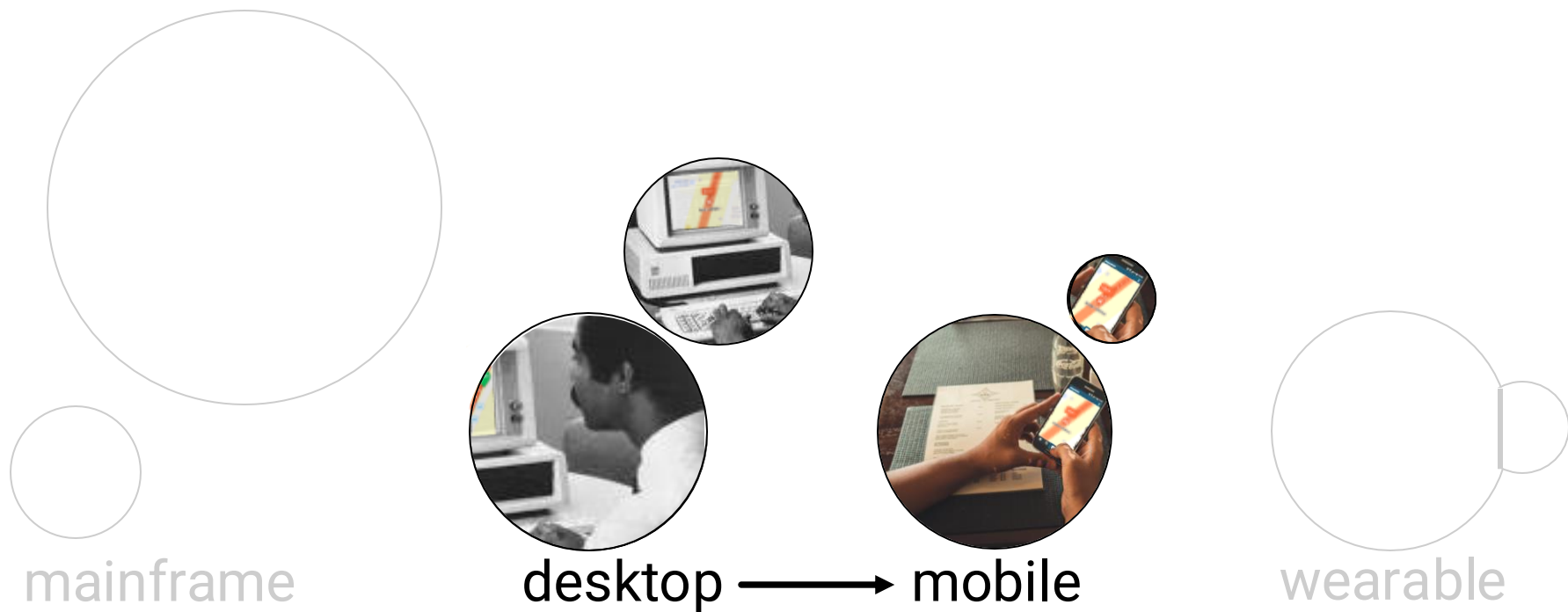
each evolution-step brought **unique benefits**



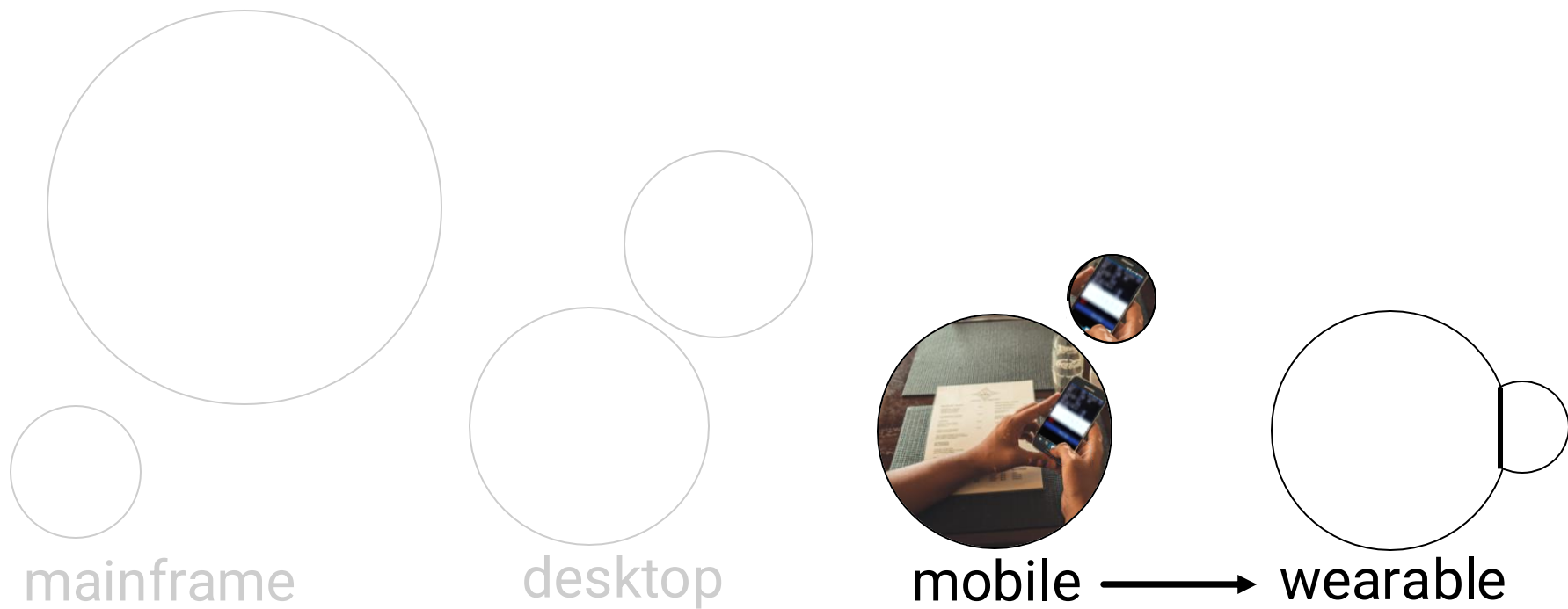
each evolution-step brought **unique benefits**
e.g., create interactions **not possible before**



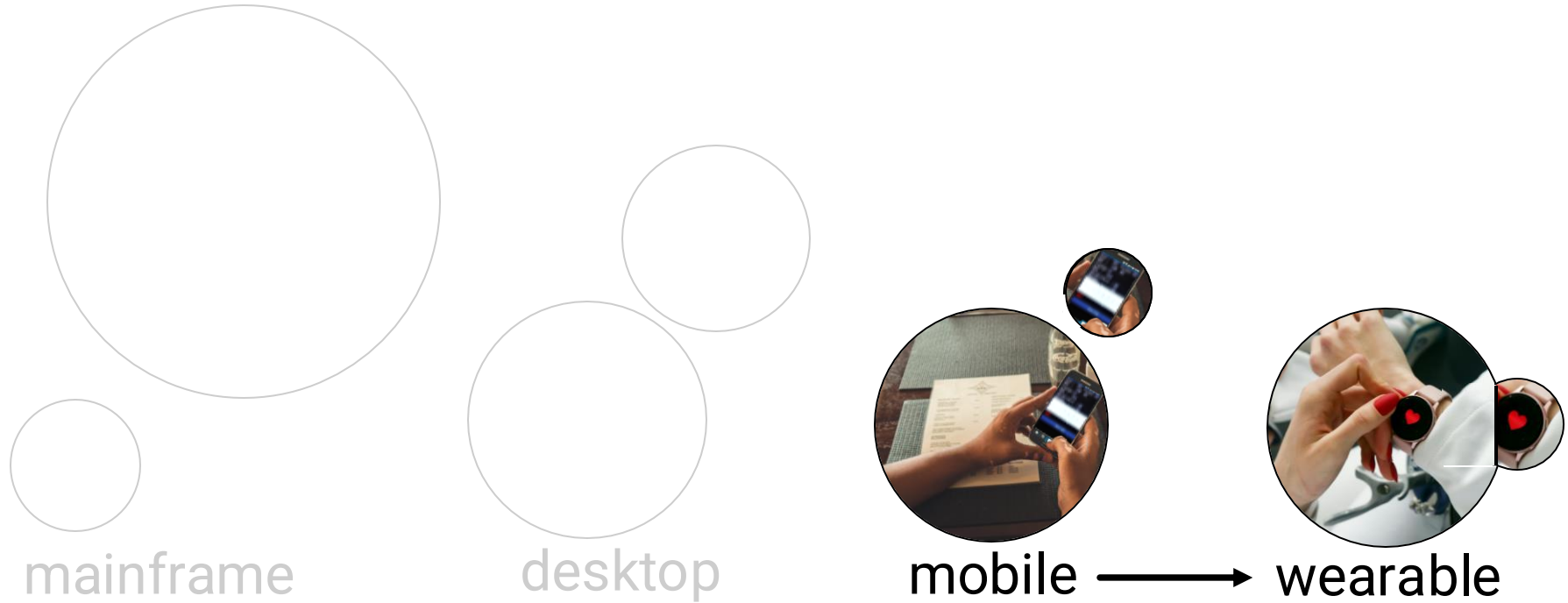
each evolution-step brought **unique benefits**
e.g., maps on desktop did not change society



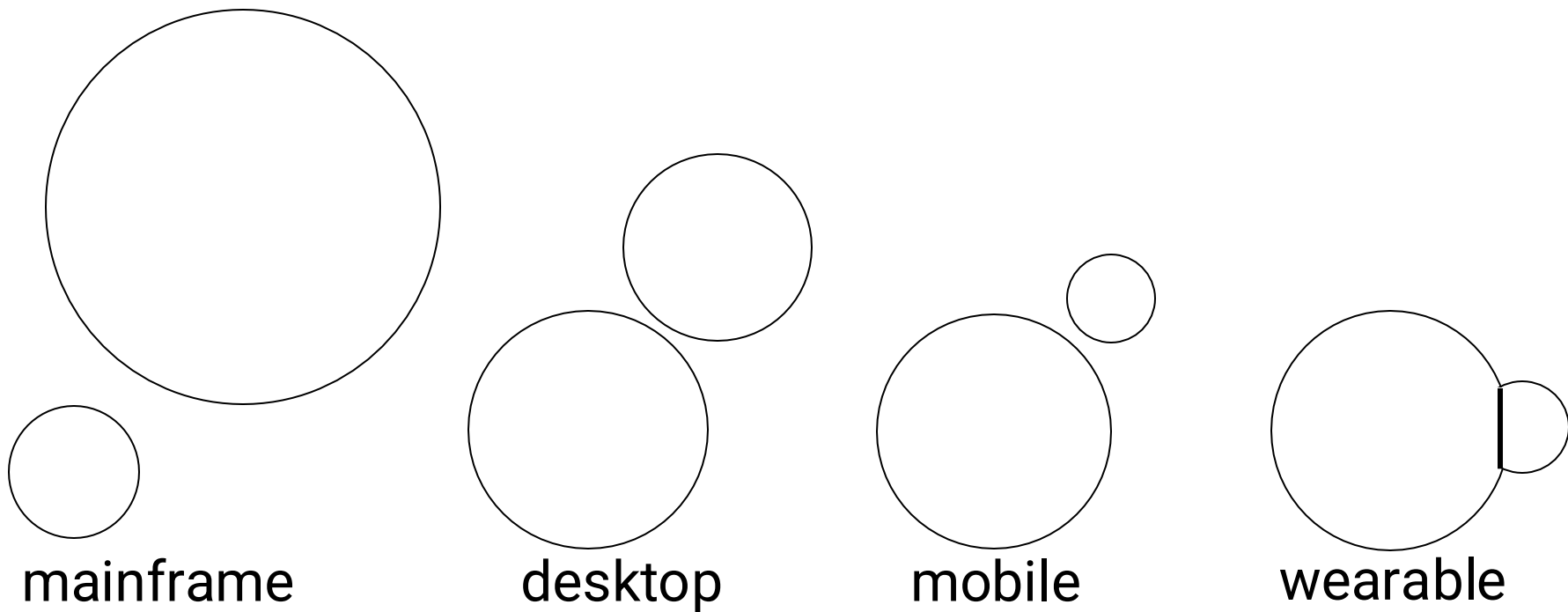
each evolution-step brought **unique benefits**
e.g., maps on desktop did not change society
but mobile **interactive maps on** changed us



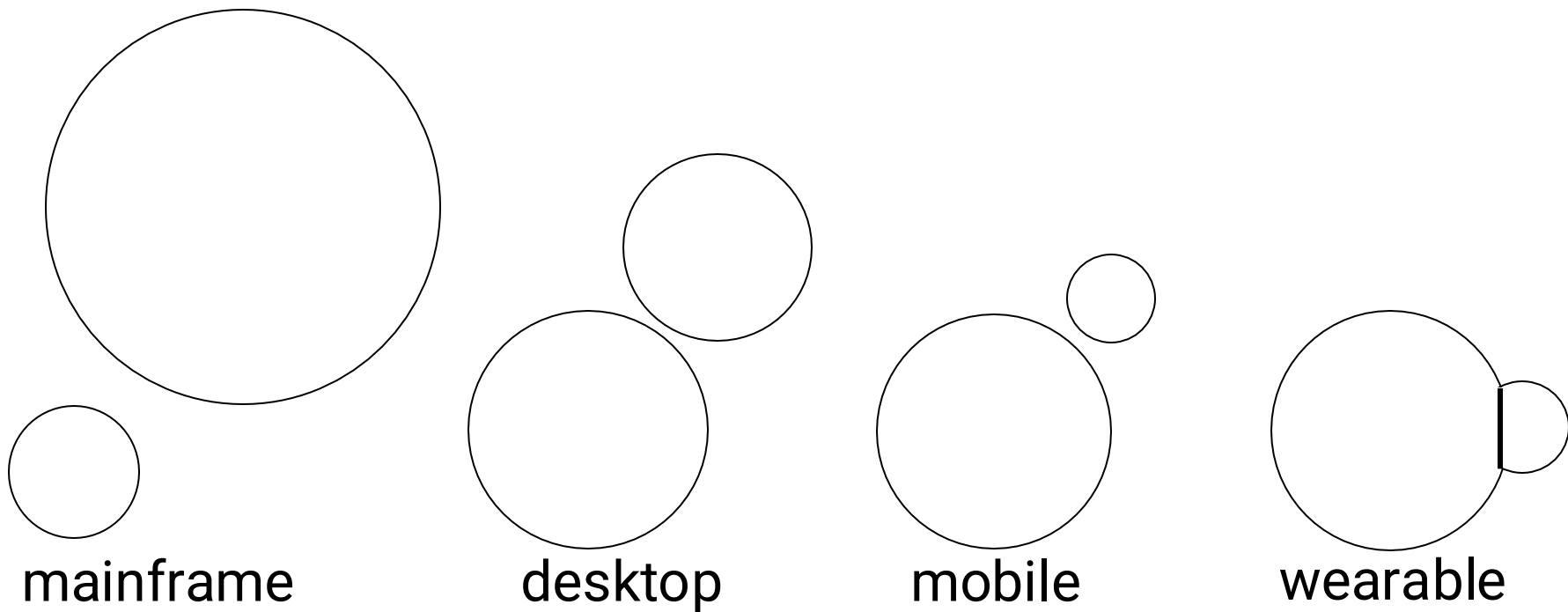
each evolution-step brought **unique benefits**
e.g., body-data on mobile was not revolutionary



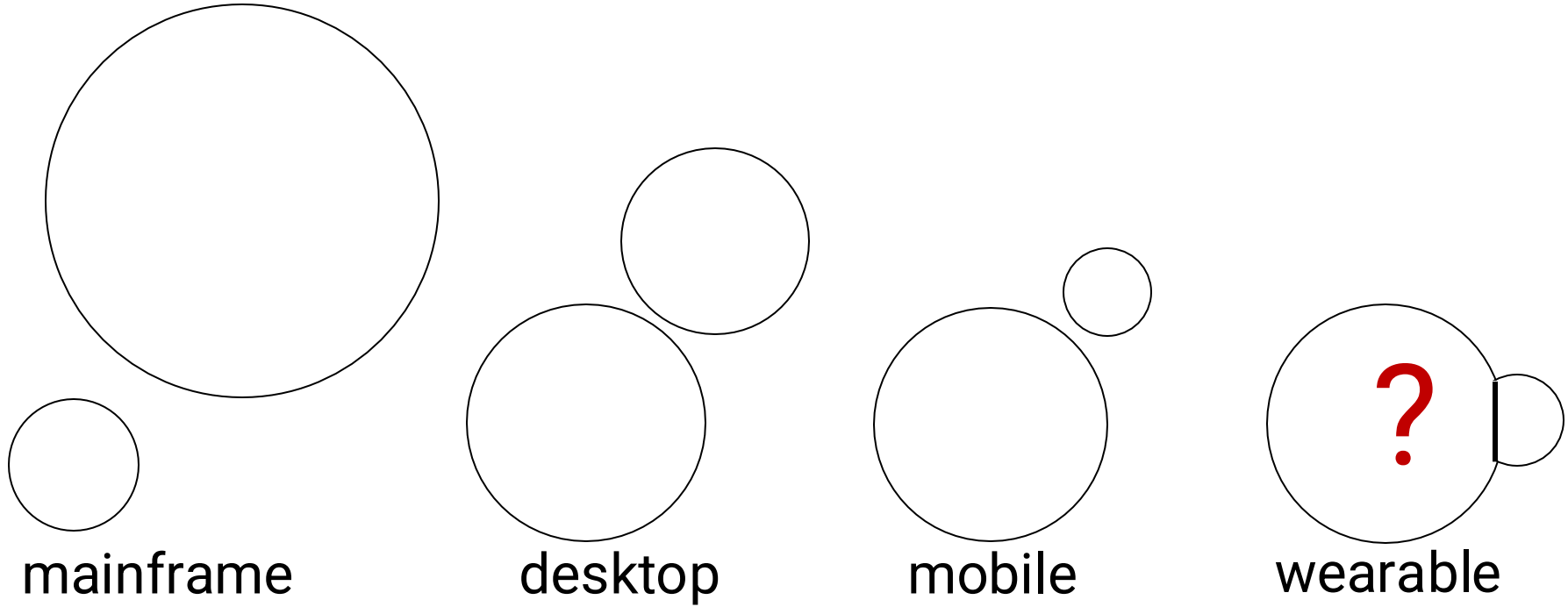
each evolution-step brought **unique benefits**
e.g., body-data on mobile was not revolutionary
but it in a **wearable** it created **a new movement**



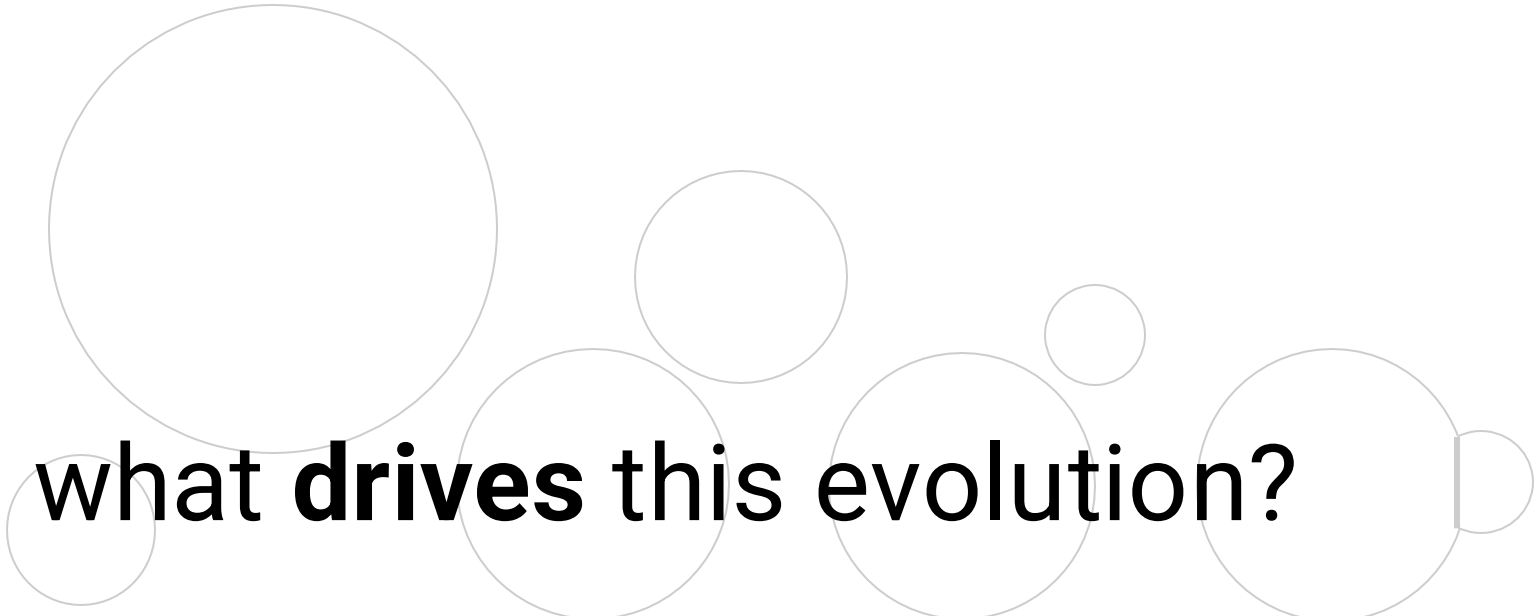
if each evolution-step of computer interfaces **proved useful**



if each evolution-step of computer interfaces **proved useful**
imagine the **value we could derive** from ...



if each evolution-step of computer interfaces **proved useful**
imagine the **value we could derive** from **the next-gen interface**



what **drives** this evolution?

mainframe

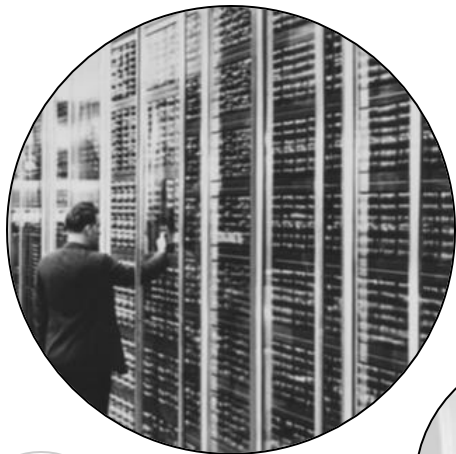
desktop

mobile

wearable

what's next?

?



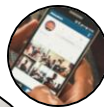
mainframe



desktop



mobile



wearable



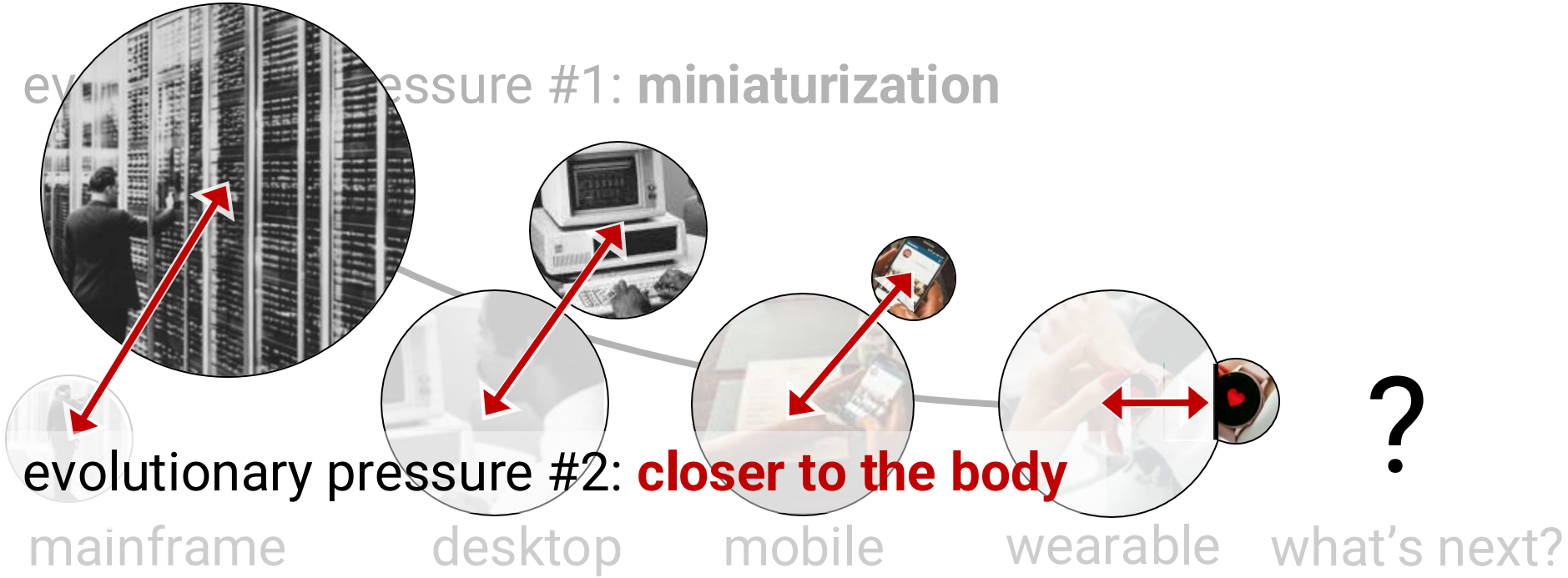
what's next?

?

evolutionary pressure #1: **miniaturization**



evolutionary pressure #1: miniaturization



evolutionary pressure #1: **miniaturization**

evolutionary pressure #2: **closer to the body**

mainframe

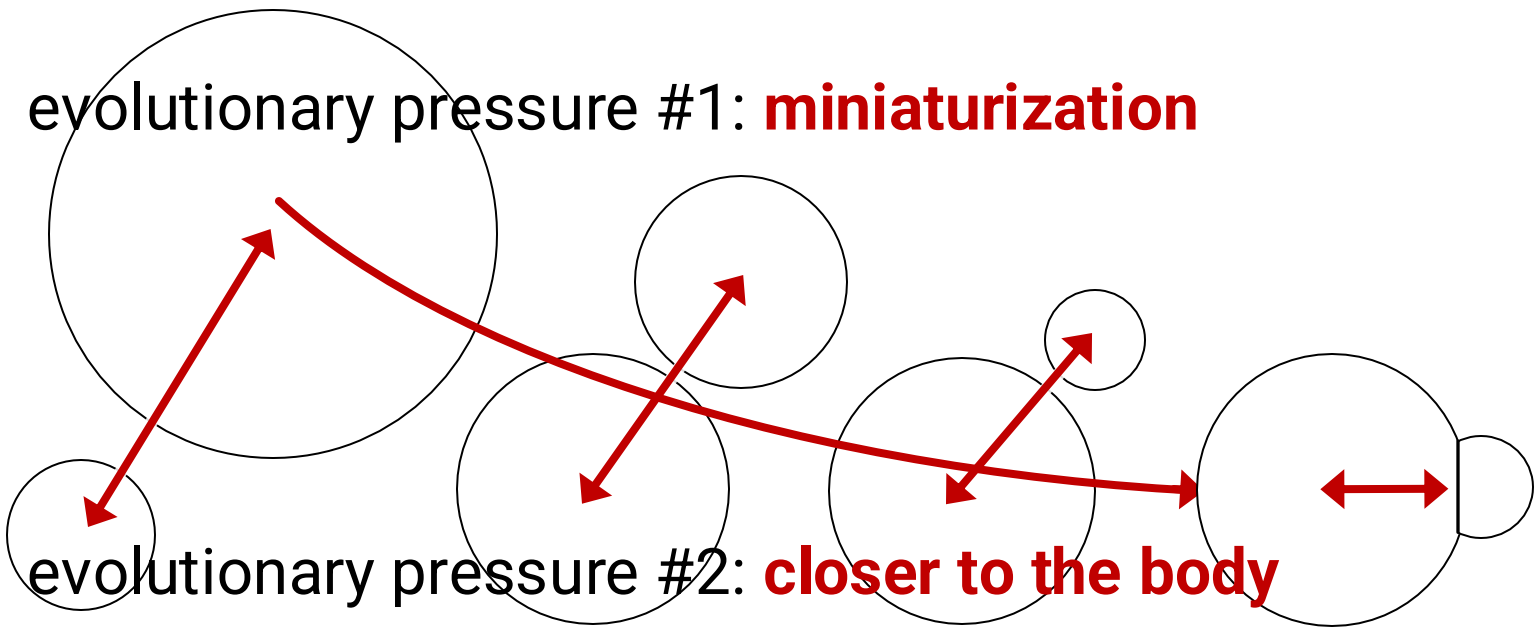
desktop

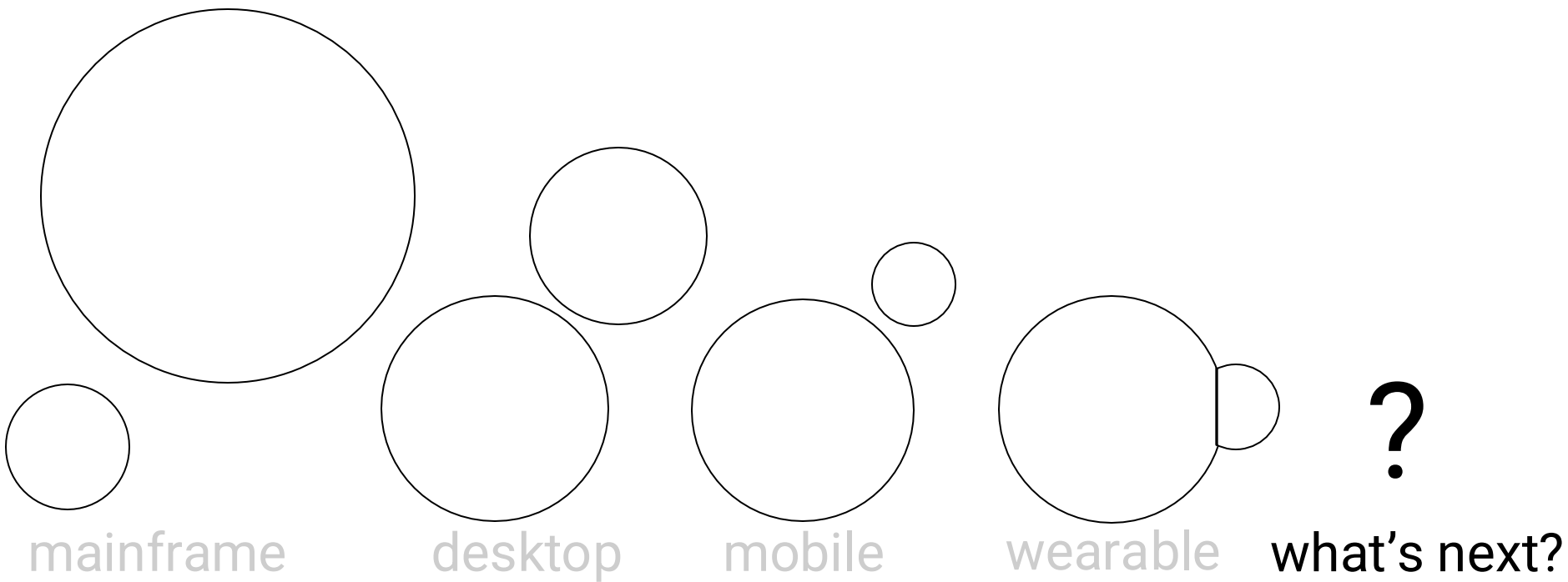
mobile

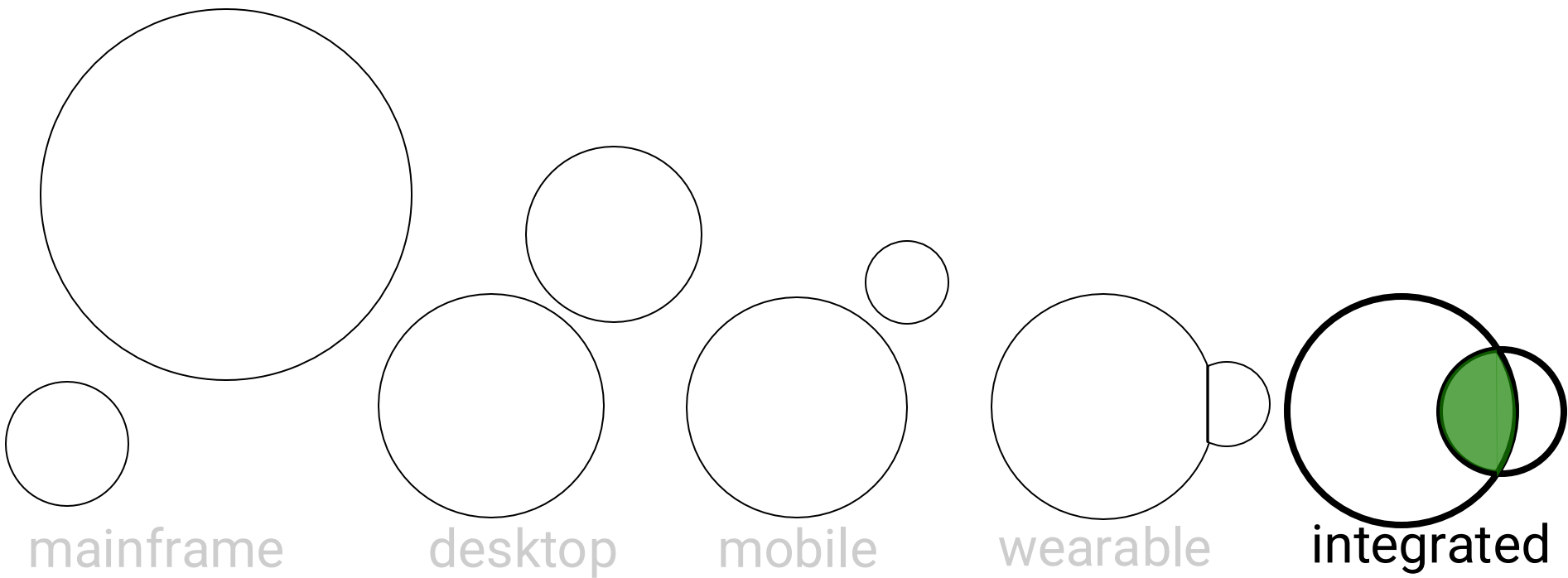
wearable

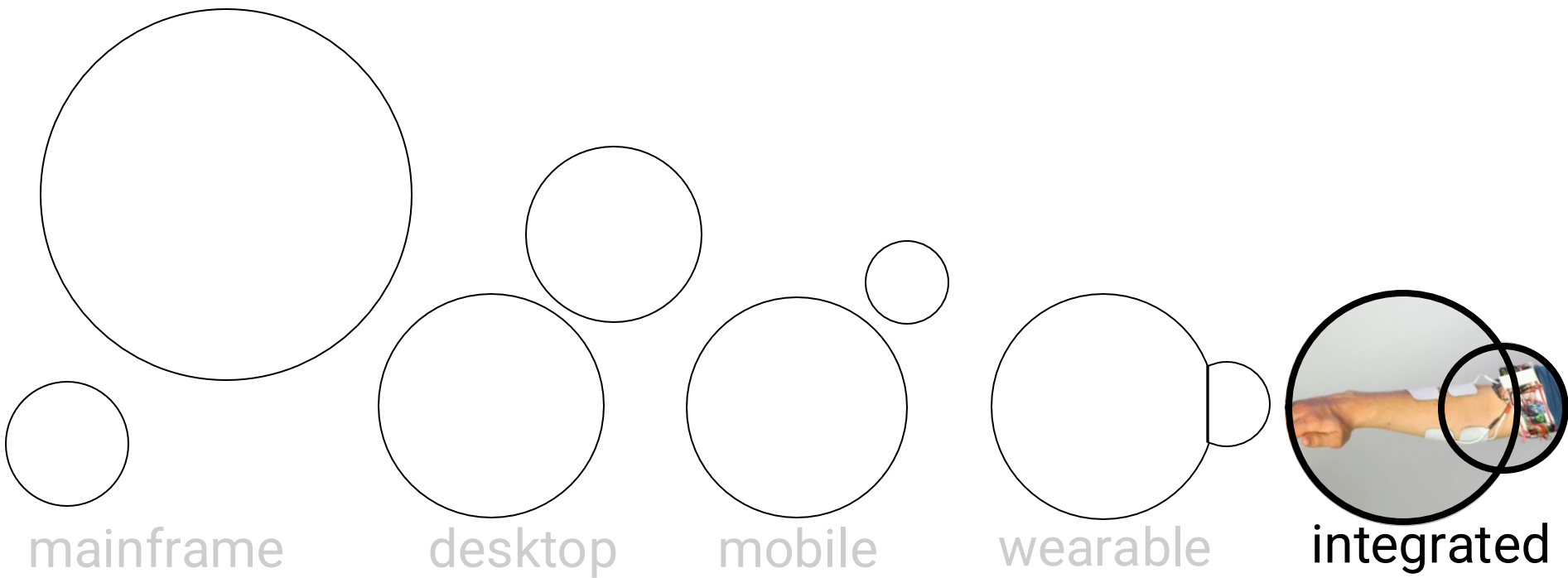
what's next?

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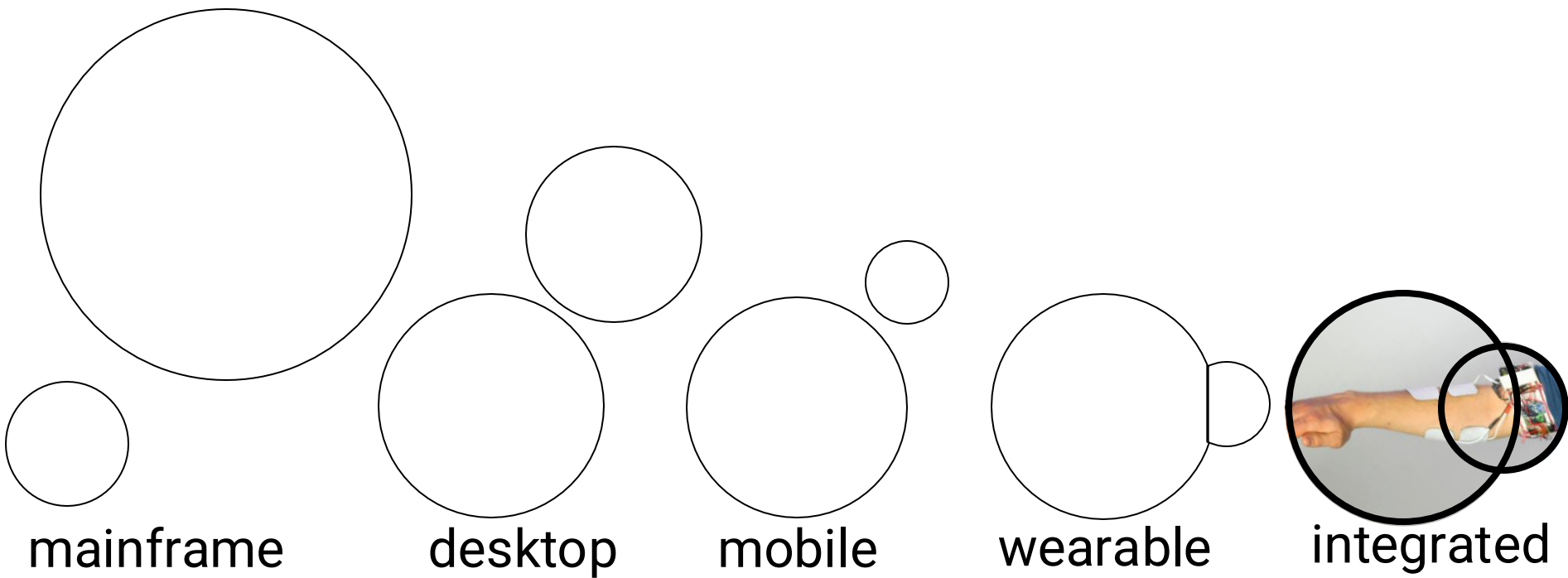








new system by Romain Nith & Yun Ho
<https://arxiv.org/abs/2505.10648>



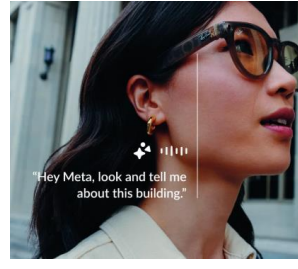
Nishida & Suzuki, 2017, CHI



humane's AI pin



meta's AI glasses



S. Imbrie with a touch-implant
Bensmaia/Greenspon et al. nature comm.



NFC/RFID implants



teslasuit



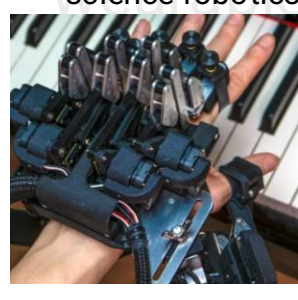
Clode/Makin et. al,
science robotics



MATE-XB exoskeleton

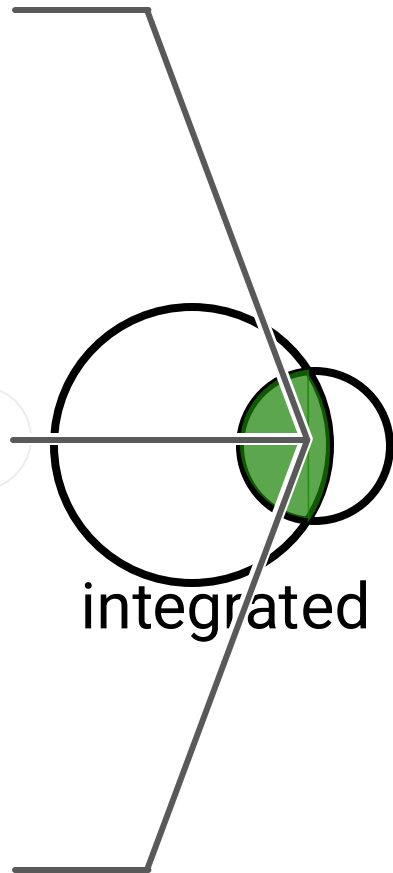


Furuya et. al, 2025
science robotics



mainframe

integrated



integration **benefits**

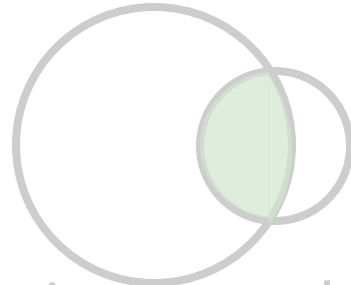
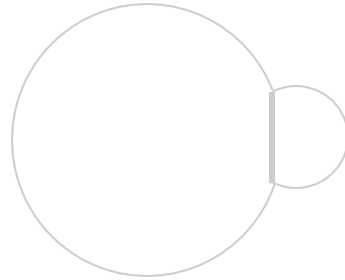
mainframe

desktop

mobile

wearable

integrated





integration benefits: **miniaturization**
new user-centered
ways of thinking
new abilities

mainframe

desktop

mobile

wearable

integrated

Pose-IO
Lopes, CHI'15



game

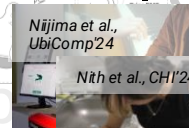
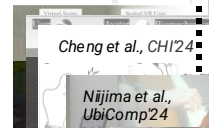
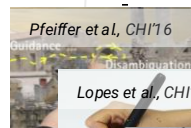
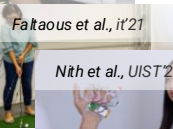
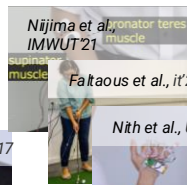
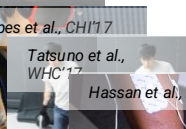
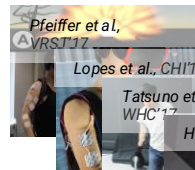
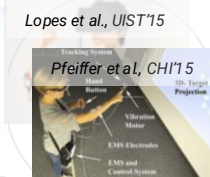
desktop

mobile

wearable

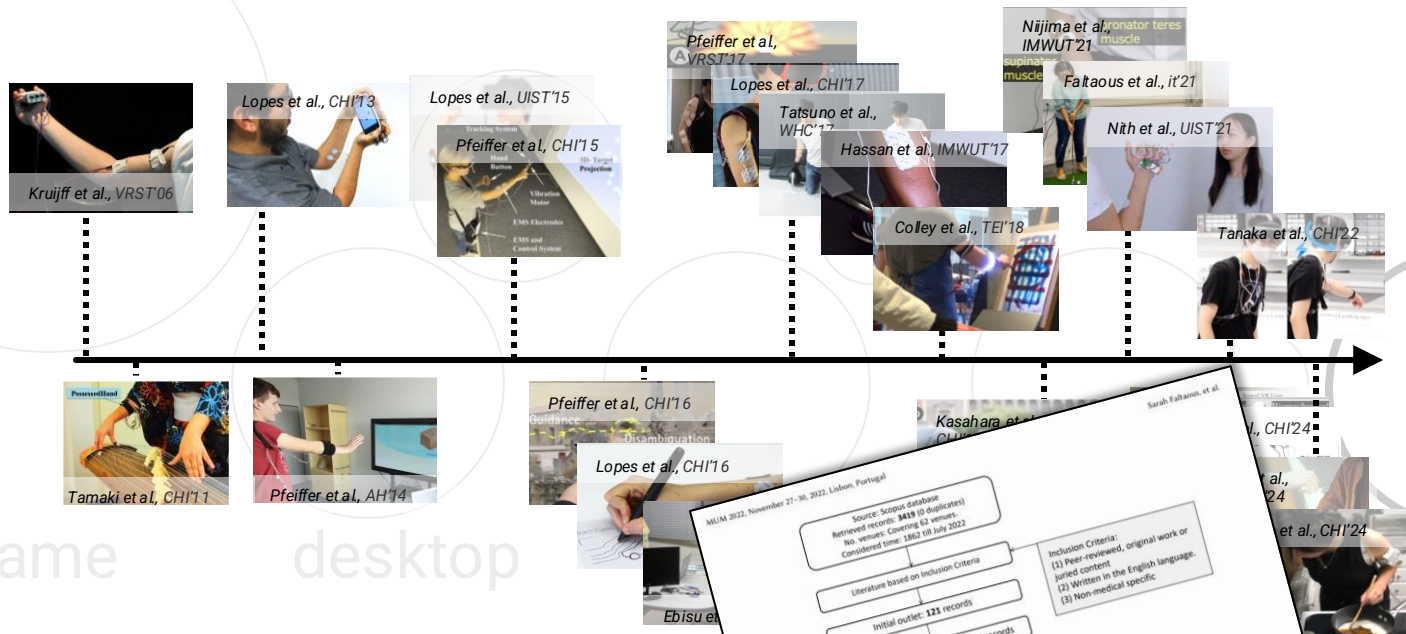
integrated

Pose-IO
Lopes, CHI'15



[timeline by Yun Ho & Romain Nith, apropos CHI'25 talk]

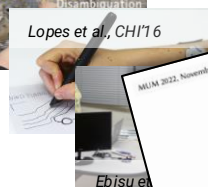
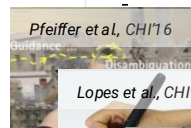
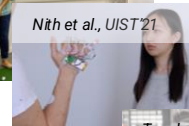
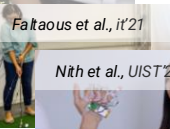
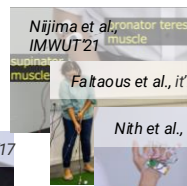
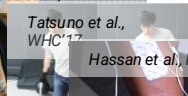
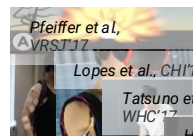
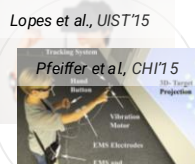
Pose-IO
Lopes, CHI'15



151 papers (as of 2022)
Faltaous et al., MUM'22

Fig. 2. Literature selection process: we started by checking the online database (i.e., Scopus) leading to a primary set of records that fits our inclusion criteria. Afterward, we checked the references of the primary set (i.e., backward chaining), ending up with 151 research publication according to its primary research contribution. Two research publication into three main types of contribution (cf., Figure 1). First EMS artifacts as second type is Theory ($N = 21$) and EMS requirements.

Pose-IO
Lopes, CHI'15



Sarah Falkner et al.



why the excitement?

151 papers (as of 2022)
Faltous et al., MUM'22

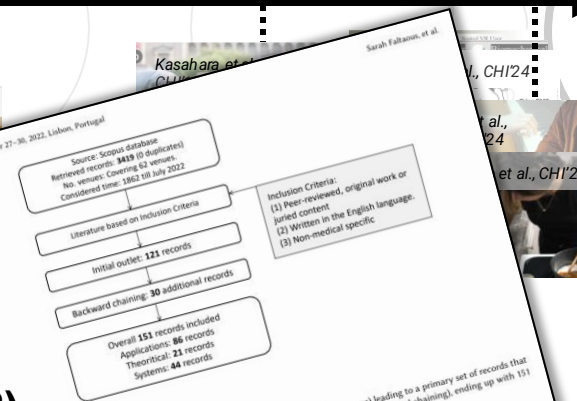


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Pose-IO
Lopes, CHI'15



why the excitement?

game

desktop

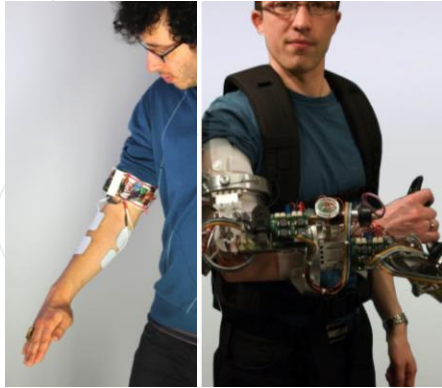
mobile

wearable

integrated

Pose-IO
Lopes, CHI'15

EXO-UL7, Perry et al., 2009
Applied Bionics & Biomech



why the excitement?
integrating with body **circumvents**
limitations of traditional interfaces

desktop

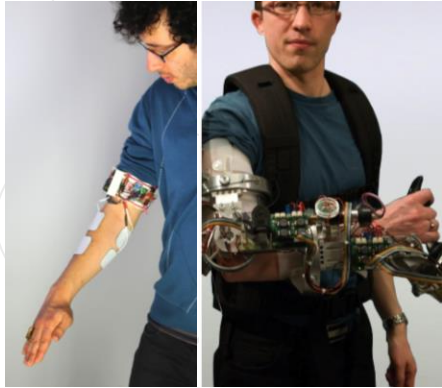
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Pose-IO
Lopes, CHI'15

EXO-UL7, Perry et al., 2009
Applied Bionics & Biomech



why the excitement?
integrating with body **circumvents**
limitations of traditional interfaces
since **directly stimulating neurons**
results in much **smaller interfaces**

desktop

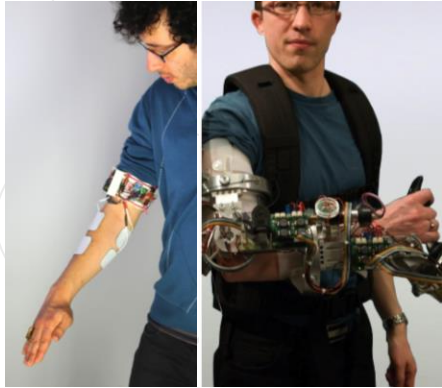
mobile

wearable

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Pose-IO
Lopes, CHI'15

EXO-UL7, Perry et al., 2009
Applied Bionics & Biomech



force-feedback

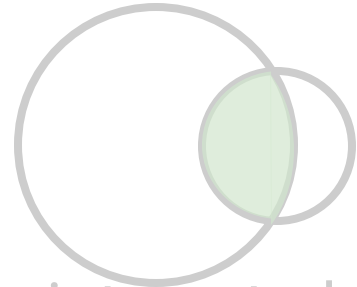
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desktop

mobile

wearable

integrated



Pose-IO
Lopes, CHI'15



EXO-UL7, Perry et al., 2009
Applied Bionics & Biomech



force-feedback

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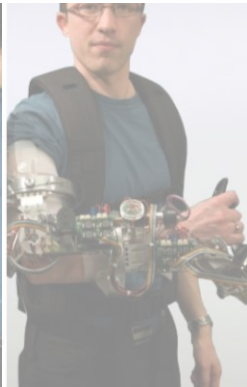


desktop mobile wearable integrated

Pose-IO
Lopes, CHI'15



EXO-UL7, Perry et al., 2009
Applied Bionics & Biomech



force-feedback

thermal lamps
Buckey et al.



temperature

chemical thermal illusion
Brooks et al. CHI'20



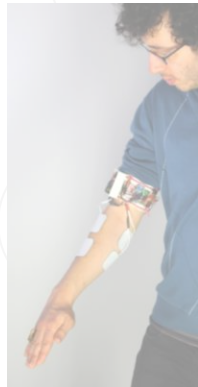
file

wearable

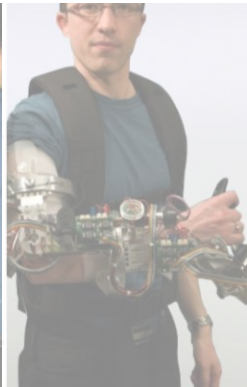
integrated



Pose-IO
Lopes, CHI'15



EXO-UL7, Perry et al., 2009
Applied Bionics & Biomech



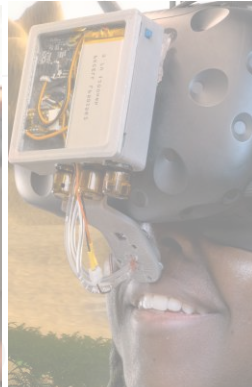
force-feedback

thermal lamps
Buckey et al.

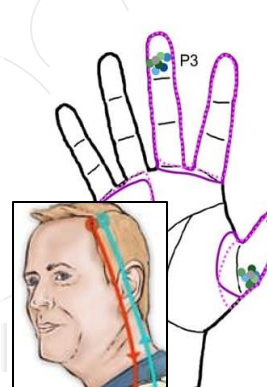


temperature

chemical thermal illusion
Brooks et al. CHI'20

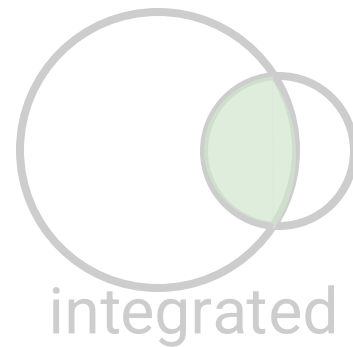


Ortiz-Catalan, Greenspon,
Bensmaia et al., Cell Reports'20



touch

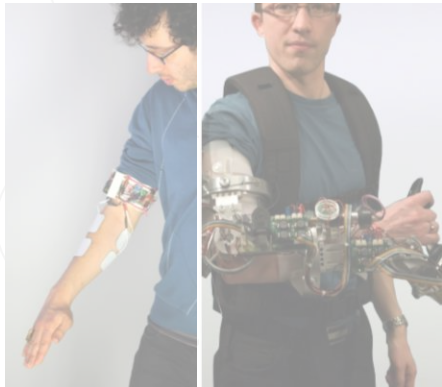
Glove, Meta
Reality Labs





Pose-IO
Lopes, CHI'15

EXO-UL7, Perry et al., 2009
Applied Bionics & Biomech



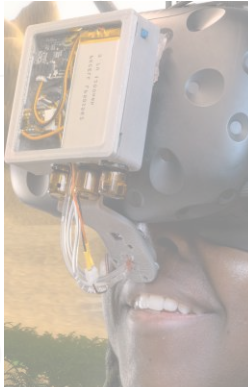
force-feedback

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Buckey et al.

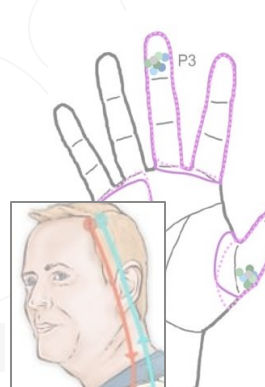


temperature

chemical thermal illusion
Brooks et al. CHI'20



Ortiz-Catalan, Greenspon,
Bensmaia et al., Cell Reports'20



touch

Glove, Meta
Reality Labs



Implanted User Interfaces
Holz et. al., CHI'12



I/O



integration benefits: miniaturization
new user-centered
ways of thinking
new abilities

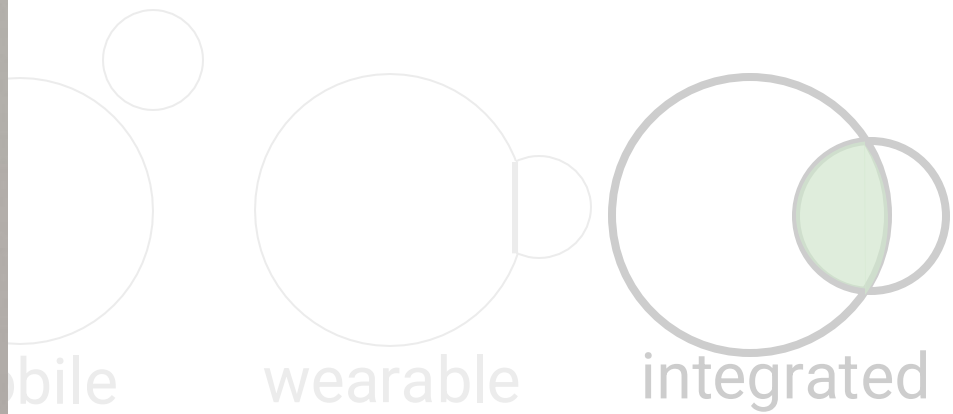
mainframe

desktop

mobile

wearable

integrated



devices are **external**



mainframe

top

mobile

wearable

integrated

devices are **external**



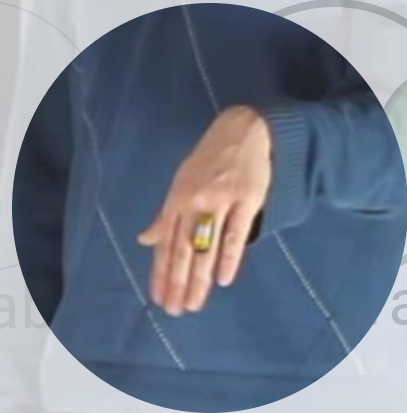
devices are **external**



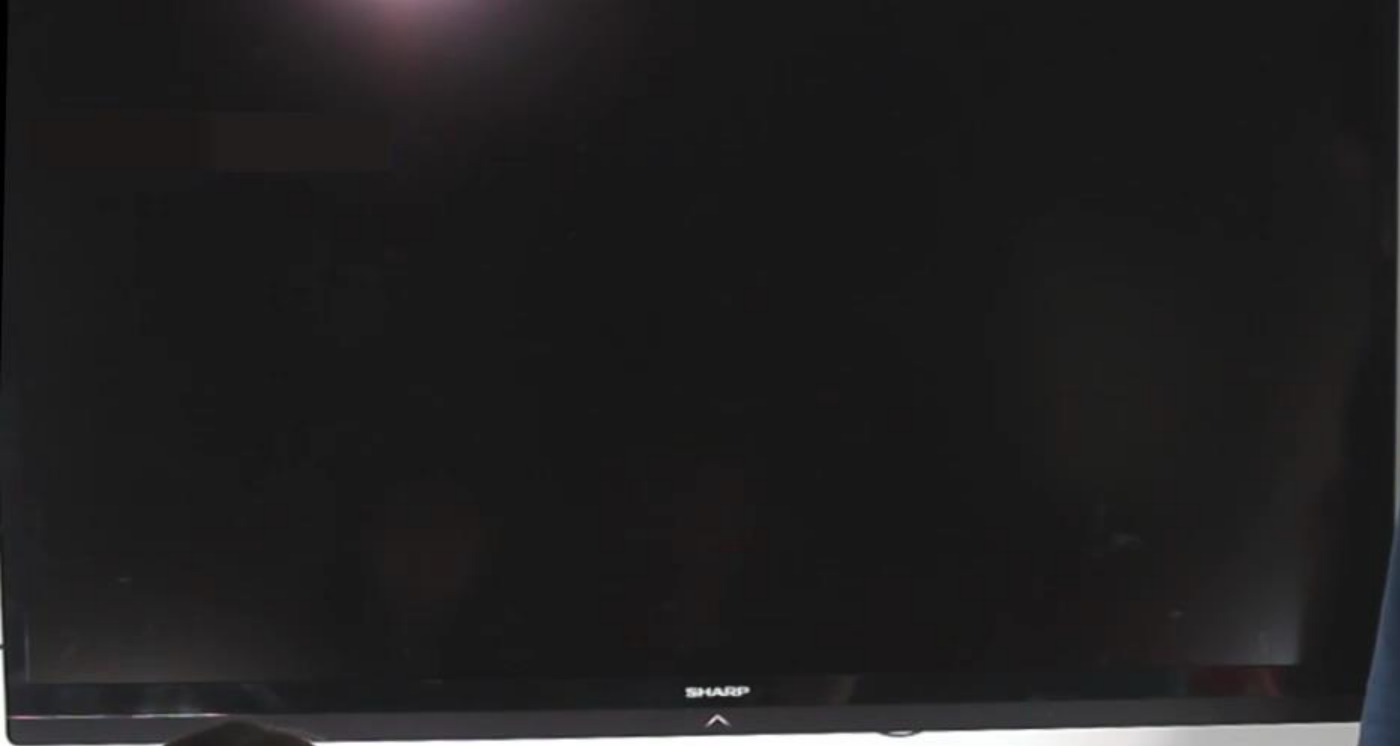
mainframe top

mobile

body **becomes** the device



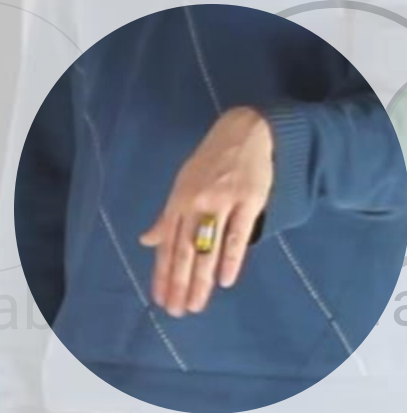
wearable integrated



devices are **external**



new meaning to user-centered
body **becomes** the device



devices are **external**

new meaning to user-centered

body **becomes** the device

replace **device-part** with **biological-part**



mainframe

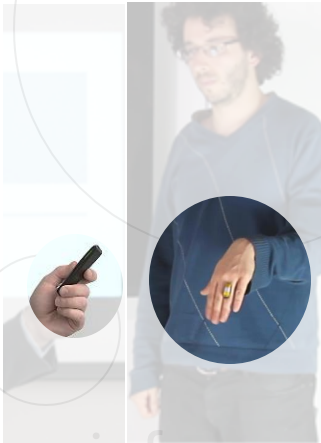
mobile

wearable

extended

replace **device-part** with **biological-part**

body as I/O device
Lopes et. al. CHI'15



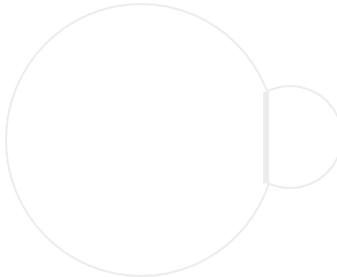
mainframe
replace handheld



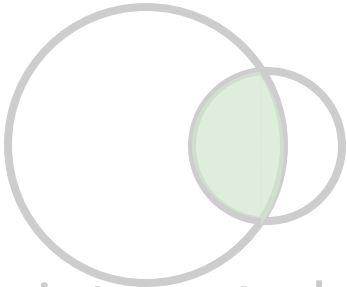
desktop



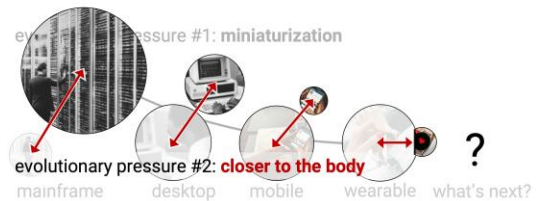
mobile



wearable

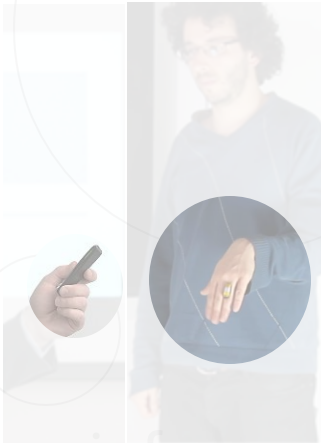


integrated



replace **device-part** with **biological-part**

body as I/O device
Lopes et. al. CHI'15

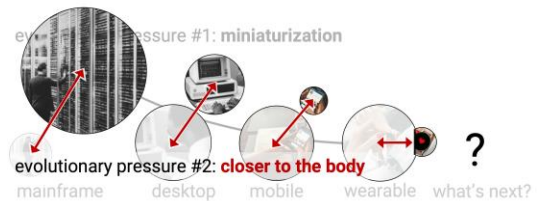


replace handheld

imaginary phone
Gustafson et. al. UIST'11



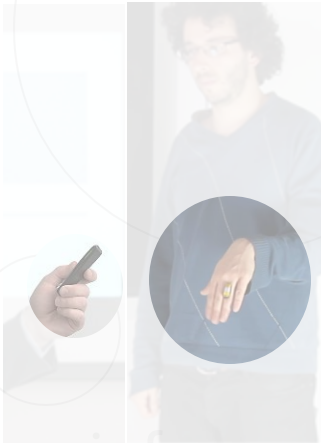
desktop mobile



wearable integrated

replace **device-part** with **biological-part**

body as I/O device
Lopes et. al. CHI'15

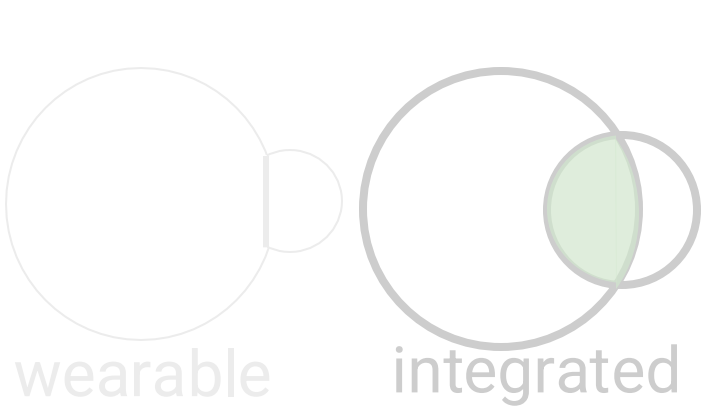
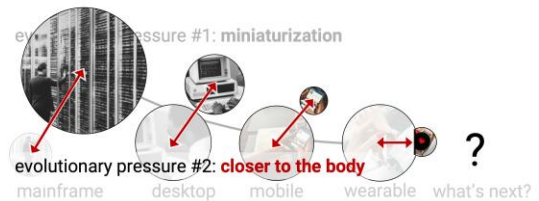


replace handheld

imaginary phone
Gustafson et. al. UIST'11

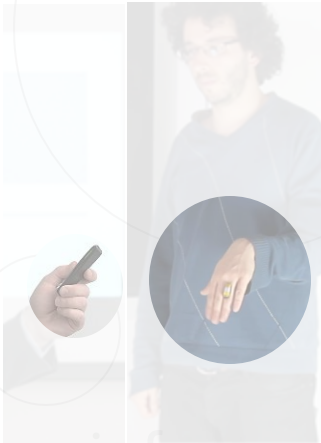


replace phone



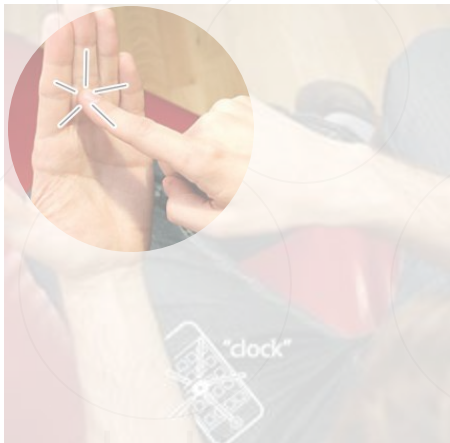
replace **device-part** with **biological-part**

body as I/O device
Lopes et. al. CHI'15



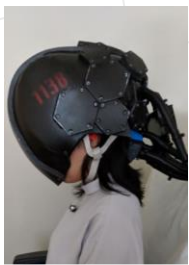
replace handheld

imaginary phone
Gustafson et. al. UIST'11



replace phone

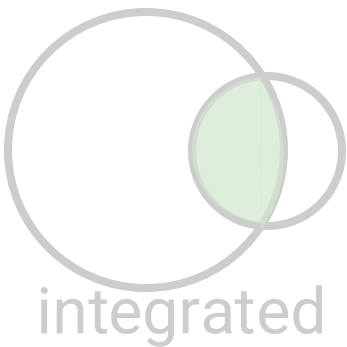
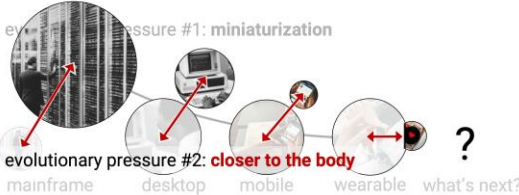
TMS phosphenes, e.g.,
Dugué et al., Cur.Bio.'16,



Novy (PhD thesis)

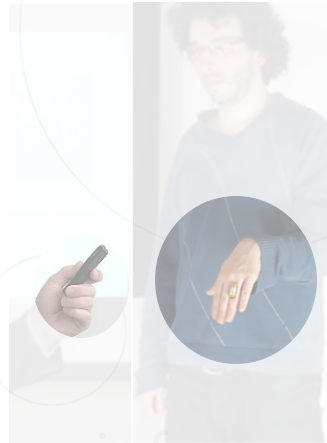
replace screens

phosphenes guidance
Higuchi et al., AH'17



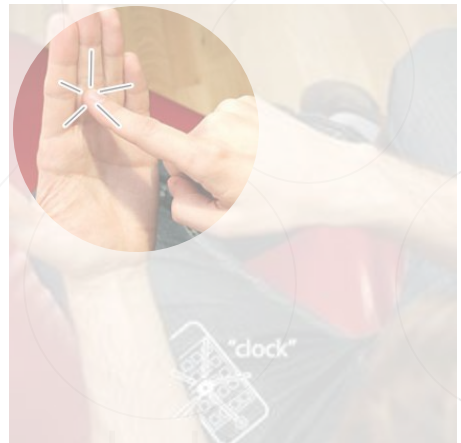
replace **device-part** with **biological-part**

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Lopes et. al. CHI'15



replace handheld

imaginary phone
Gustafson et. al. UIST'11



replace phone

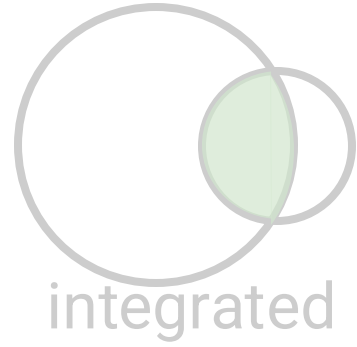
TMS phosphenes, e.g.,
Dugué et al., Cur.Bio.'16
stimulated region



Novy (PhD thesis)

replace screens

phosphenes guidance
Higuchi et al., AH'17





integration benefits: miniaturization
new user-centered
ways of thinking
new abilities

mainframe

desktop

mobile

web applications

integrated

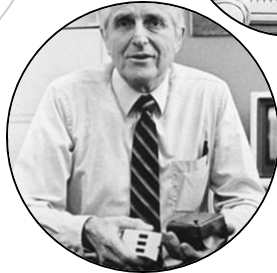
the mainstream mode of thinking with
computers is symbolic (textual, iconic)

mainframe

desktop



the mainstream mode of thinking with
computers is symbolic (textual, iconic)



mainframe

desktop



the mainstream mode of thinking with
computers is symbolic (textual, iconic)

mainframe

desktop



the mainstream mode of thinking with
computers is symbolic (textual, iconic)

mainframe

desktop

Step 1: Find the indefinite integral of $f(x)$

The integral of each term in the polynomial is calculated as follows:

$$\int (33x^5 - 106x^4 + 126x^3 + 67x^2 + 15x) dx$$

This gives:

$$\frac{33}{6}x^6 - \frac{106}{5}x^5 + \frac{126}{4}x^4 + \frac{67}{3}x^3 + \frac{15}{2}x^2 + C$$

Which simplifies to:

$$5.5x^6 - 21.2x^5 + 31.5x^4 + 22.33x^3 + 7.5x^2 + C$$

Step 2: Set the integral equal to 2

We want to find when the integral equals 2, so we set the expression equal to 2:

$$5.5x^6 - 21.2x^5 + 31.5x^4 + 22.33x^3 + 7.5x^2 + C = 2$$

This is an equation with an unknown constant C . If we assume $C = 0$ (i.e., we are looking for the value of x such that the indefinite integral equals 2 from the origin), we can solve for x .

Step 3: Solve for x

Now, we can solve the equation numerically. Let me calculate the values for x that satisfy this condition.

seems that I currently can't run the Python code unless you're logged into ChatGPT. However, you can



LLMs

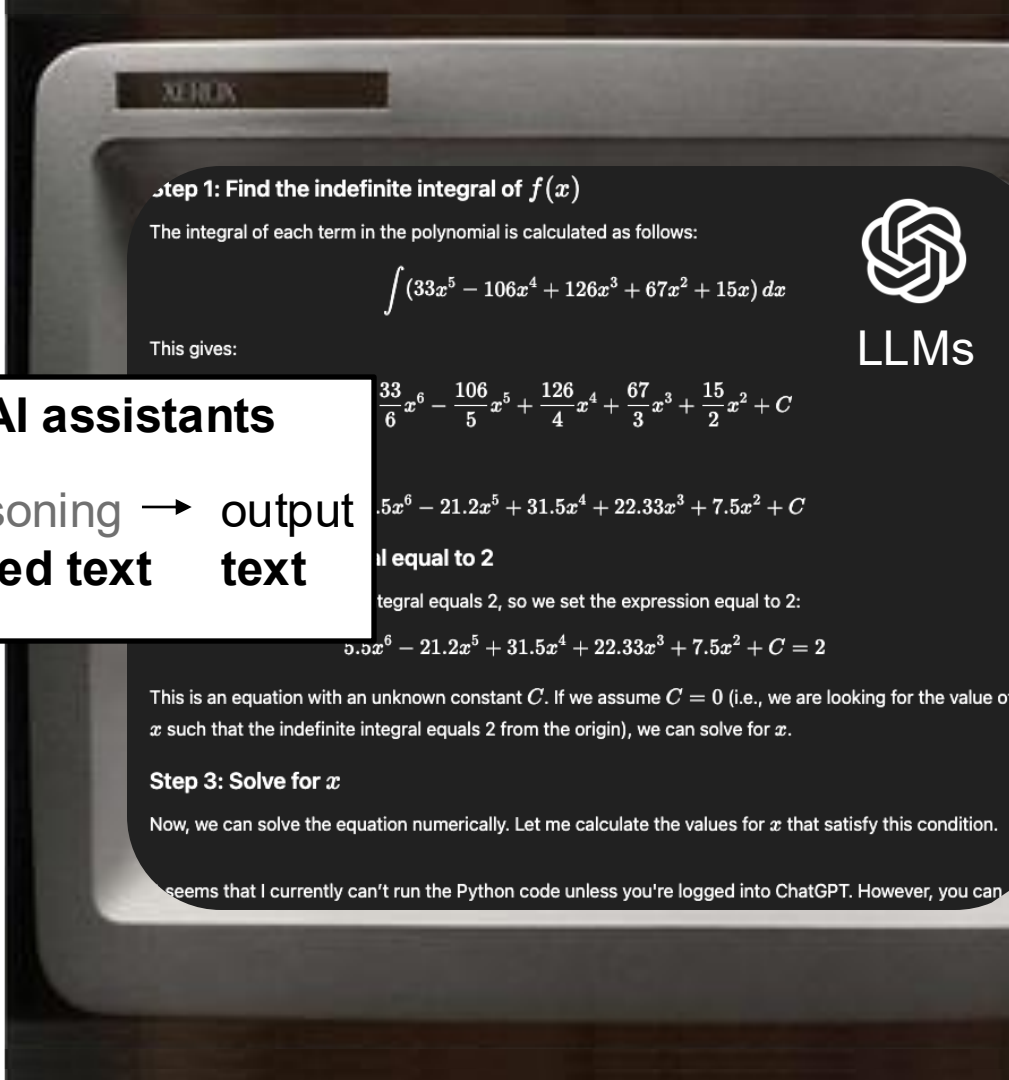
the mainstream mode of thinking with
computers is symbolic (textual, iconic)

modern AI assistants

input → reasoning → output
text learned text text

mainframe

desktop



the mainstream mode of thinking with
computers is symbolic (textual, iconic)

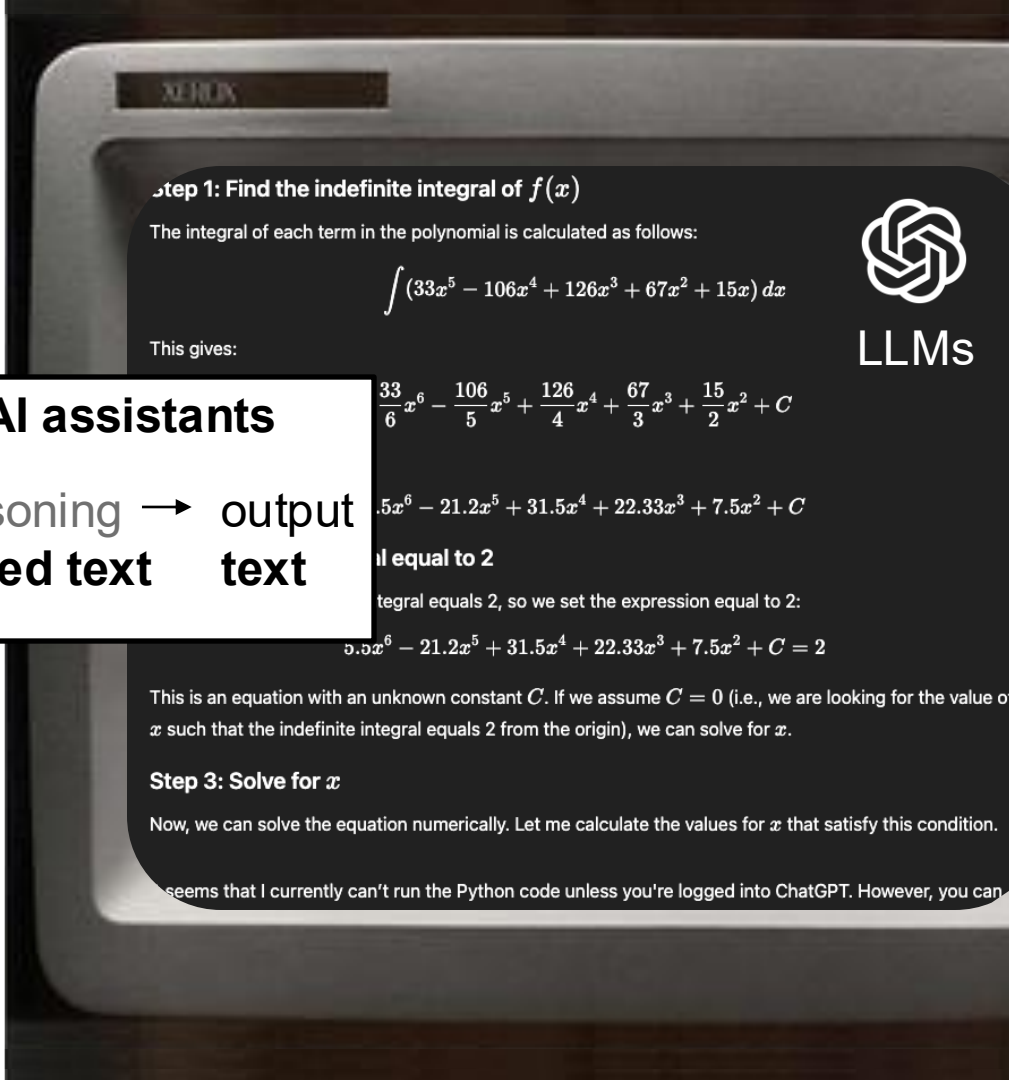
modern AI assistants

input → reasoning → output
text learned text text

mainframe

desktop

however, this does not represent the
entirety of being human, nor all of us



$F(x) = \dots x^4 + 126x^3 + -67x^2 + 15x$
PLC

integrated AI assistants

input $\rightarrow$ reasoning $\rightarrow$ output
body non-verbal body

watch video: <https://www.youtube.com/watch?v=On738nXm5AM>



Lopes et al., UIST'16

Step 1: Find the indefinite integral of $f(x)$

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$$5.5x^6 - 21.2x^5 + 31.5x^4 + 22.33x^3 + 7.5x^2 + C$$

equal to 2

integral equals 2, so we set the expression equal to 2:

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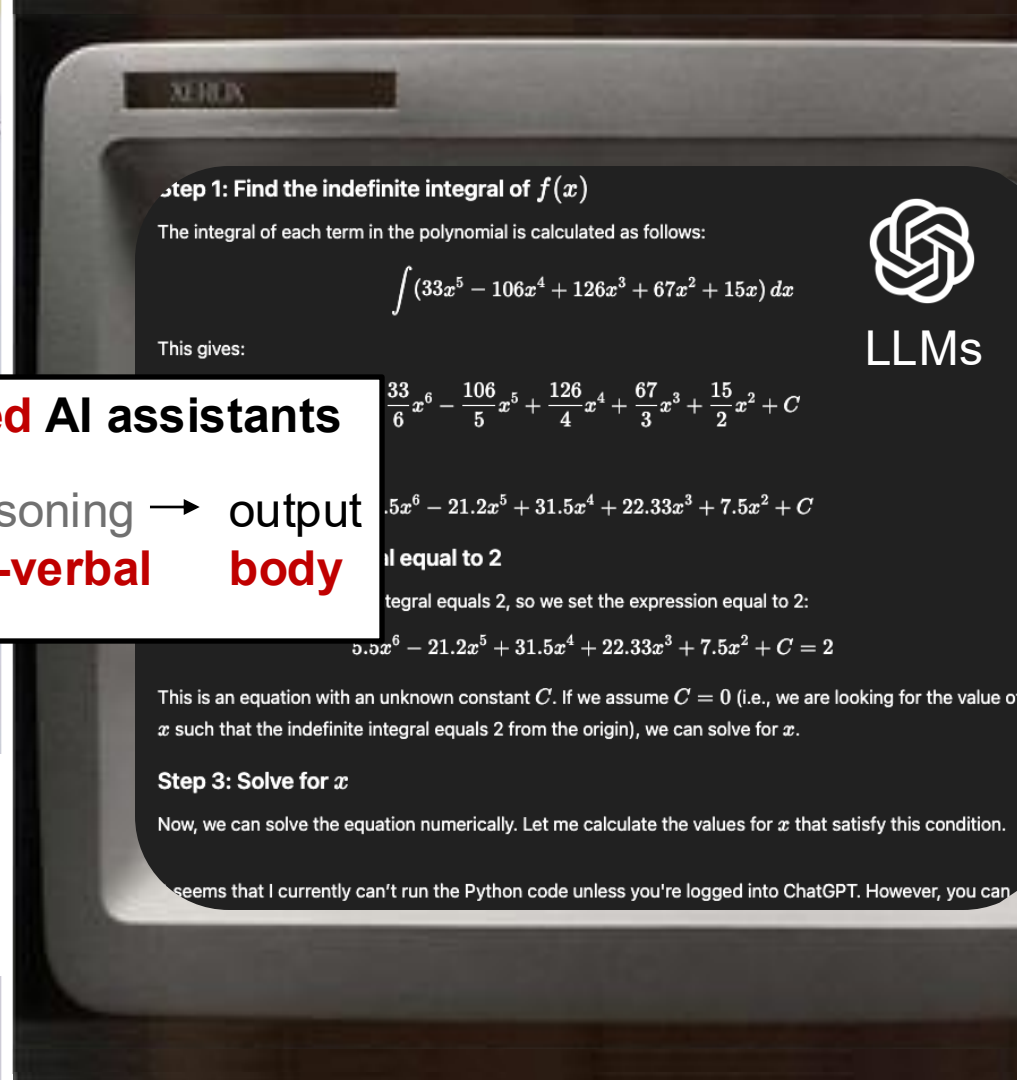
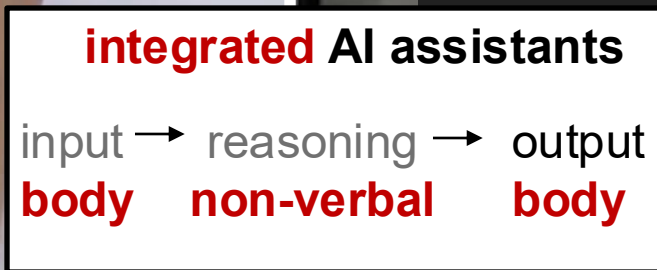
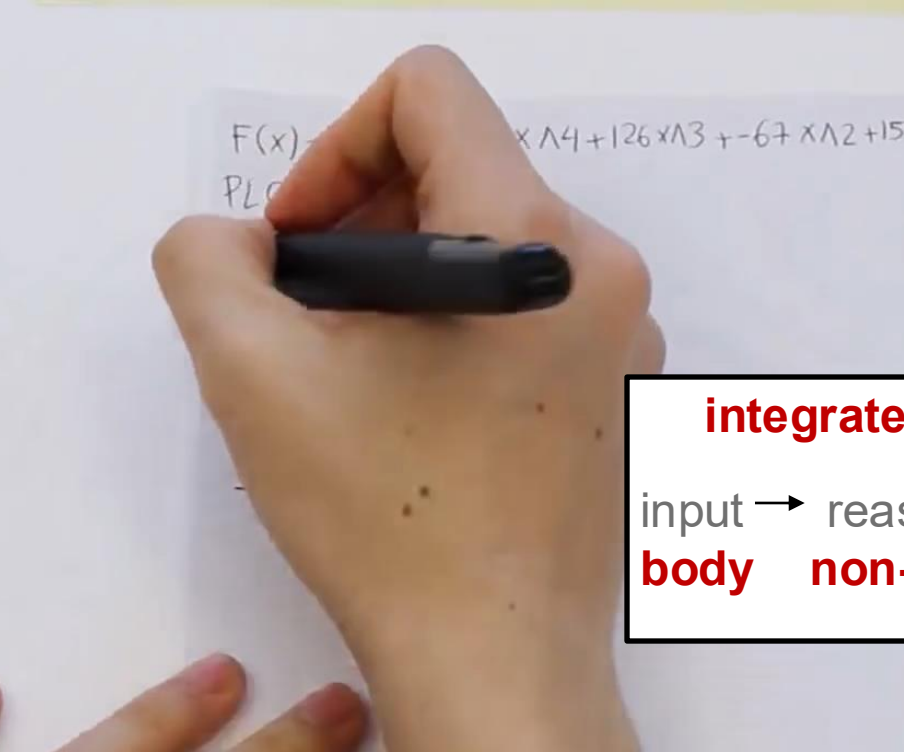
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LLMs



Explaining Math: Gesturing Lightens the Load

December 2001 · Psychological Science · 12(6):516-22
 DOI: [10.1111/1467-9280.00395](https://doi.org/10.1111/1467-9280.00395)

Susan Goldin-Meadow · Howard Nusbaum · Spencer Kelly · Susan Wagner Cook

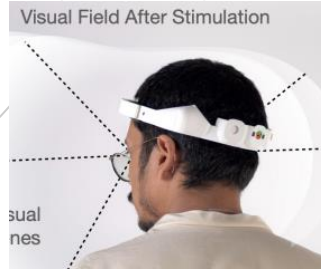
integrated interfaces allow us to explore **non-symbolic modes of reasoning** *

Lopes et al., UIST'16



physical
reasoning

Danry et al., AH'24



spatial
reasoning

Bhandarkar / Seim /
Starnier et al., ISWC'22



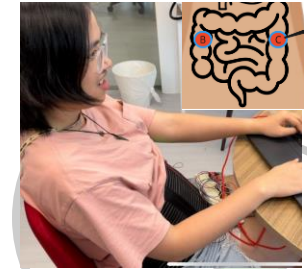
subconscious
reasoning

Horowitz et al.,
Sci. Reps.'23



unconscious
reasoning

Nguyen et. al.,
UIST EA'24



interoceptive
reasoning

* see significant shifts in last decades of HCI towards non-verbal thinking (e.g., Ishi's Tangible Bits, Höök's Soma design, and more)



integration benefits: miniaturization
new user-centered
ways of thinking
new abilities

mainframe

desktop

mobile

wearable

integrated

integration allows **endowing** users with **new abilities**



integration allows **endowing** users with **new abilities**



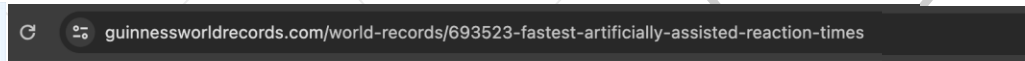
integration allows **endowing** users with **new abilities**



accelerated reactions



super human speed up with
electrical muscle stimulation



Who

**PEDRO LOPES, JUN NISHIDA,
SHUNICHI KASAHARA**

What

0.05 SECOND(S)

Where

UNITED STATES (CHICAGO)

When

MAY 2019

The fastest artificially-assisted reaction time is 50 milliseconds from stimulus to action, which was achieved using electro-muscular stimulation (EMS) by researchers from the University of Chicago (USA) and Sony CSL (JPN). A typical human reaction

integration allows **endowing** users with **new abilities**

Tanaka et al, UIST'25



accelerated reactions

mainframe

Bensmaia/Greenspon et al.,
Nature Comm.



remote touch

desktop

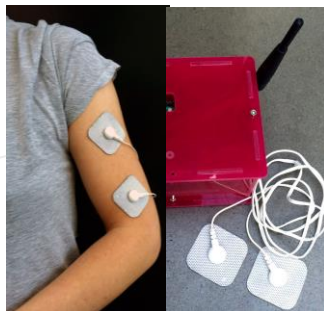
Strohmeier et al., AHS'20



feeling EM

mobile

Grönvall et al, DIS'16



feeling wifi

wearable

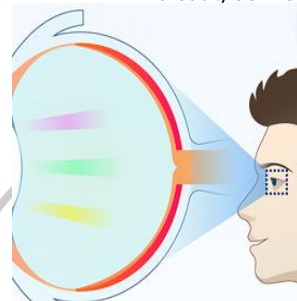
Brooks et al, CHI'21



smelling in stereo

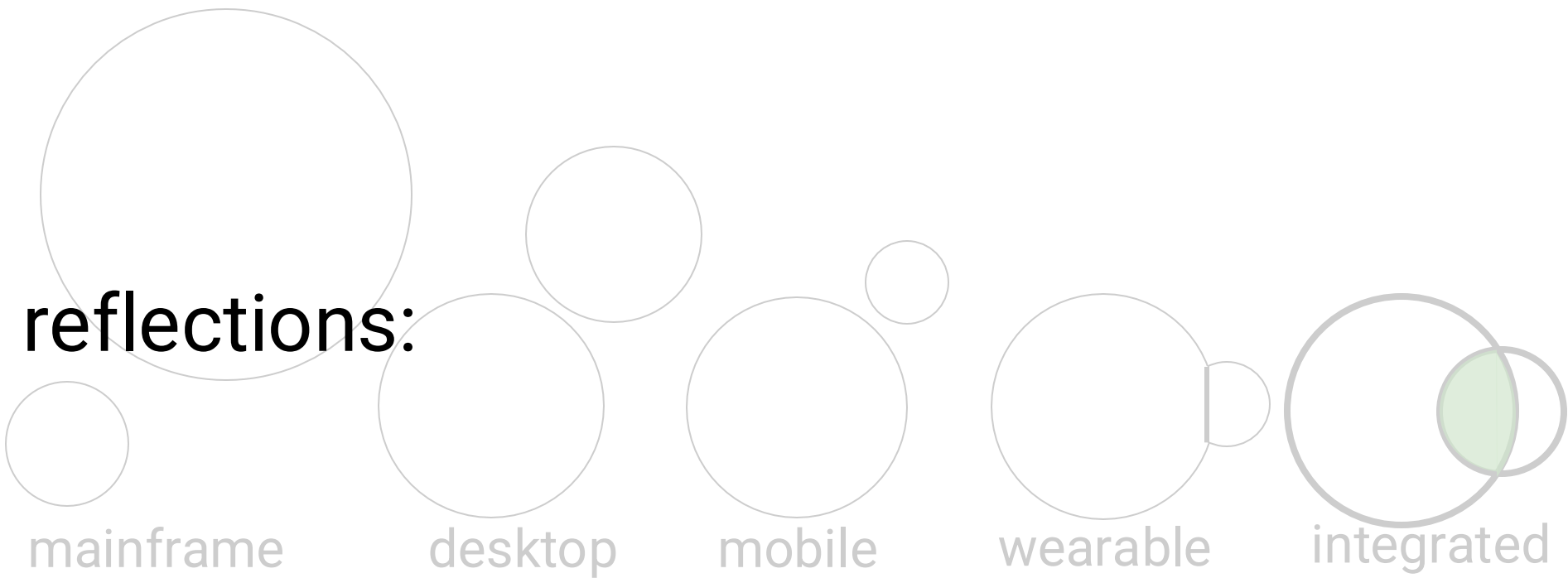
integrated

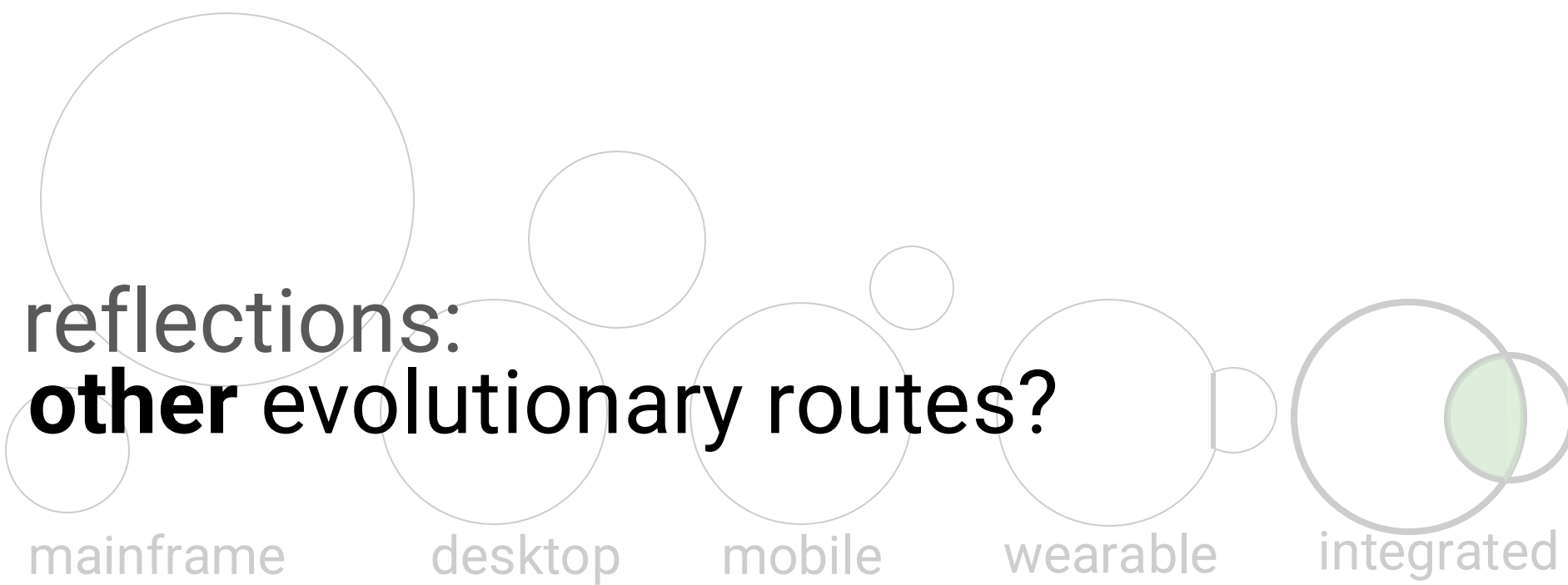
Ma et al, Cell'25



seeing near-IR

reflections:





reflections:
other evolutionary routes?

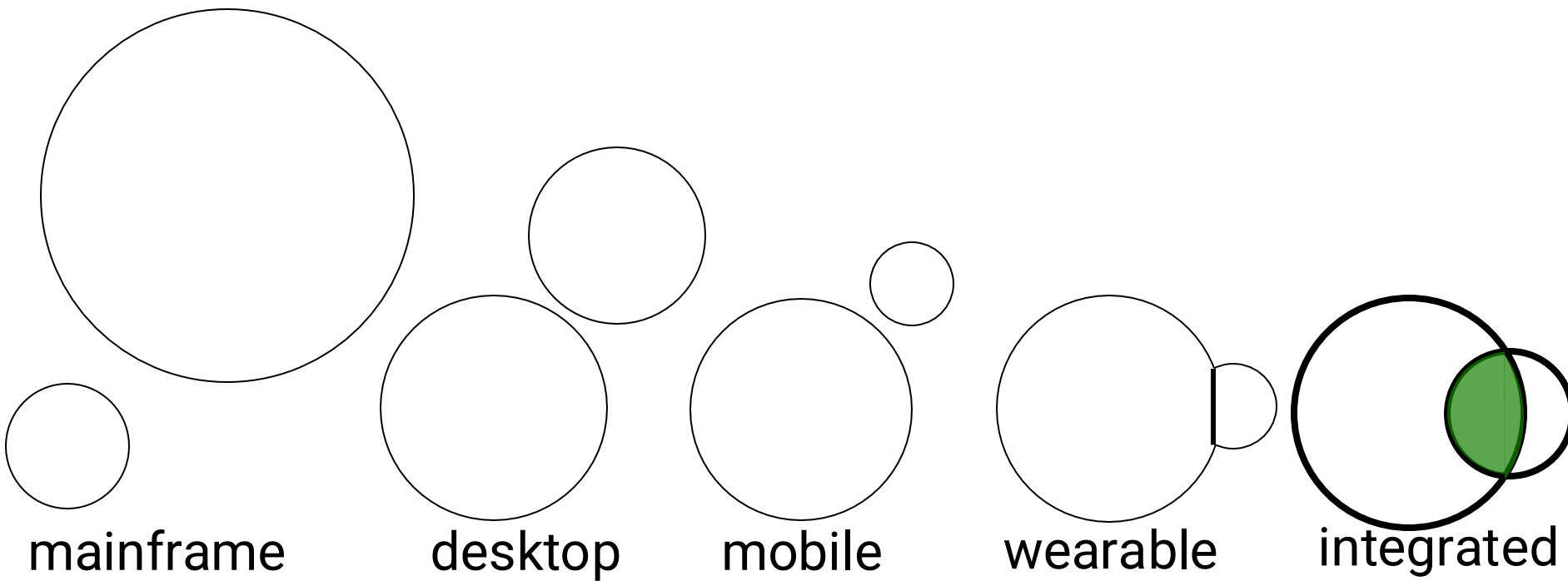
mainframe

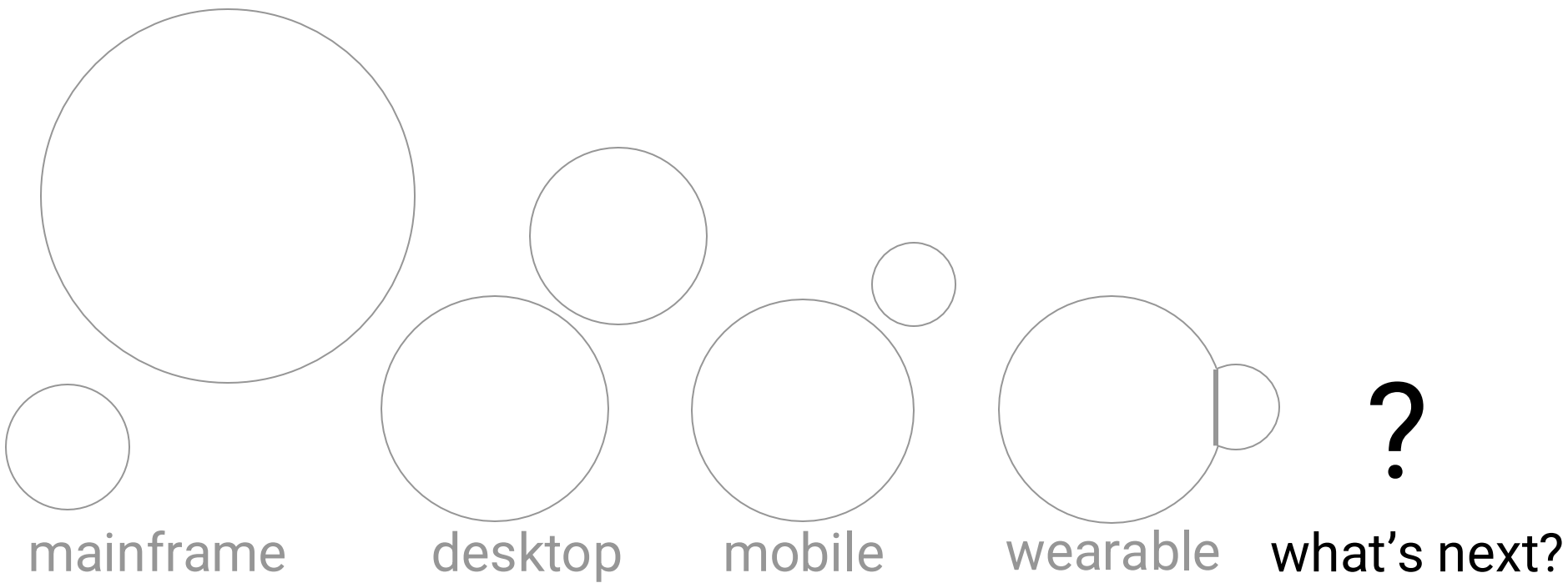
desktop

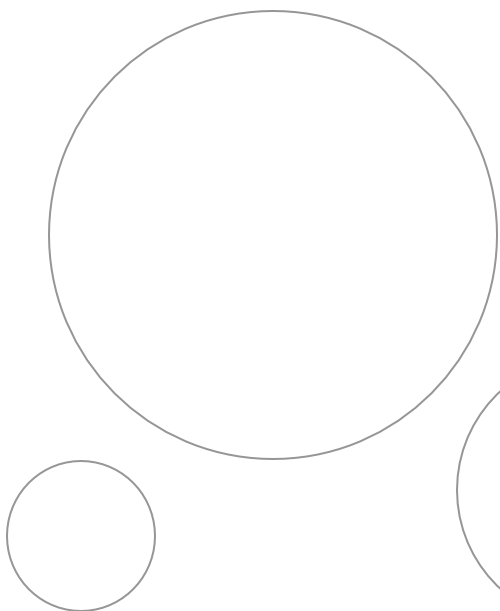
mobile

wearable

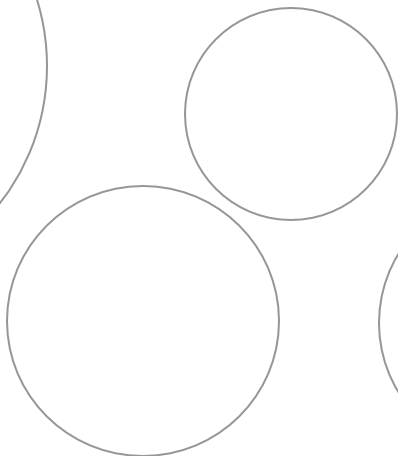
integrated



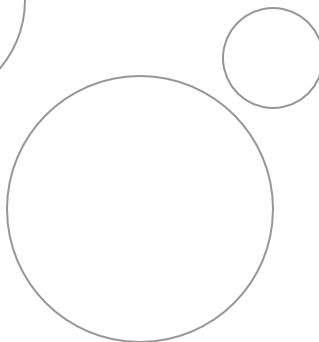




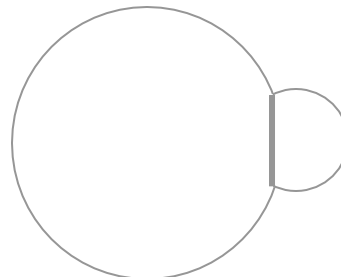
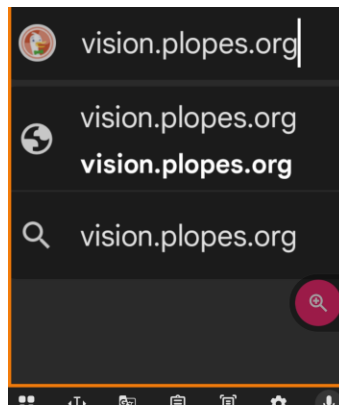
mainframe



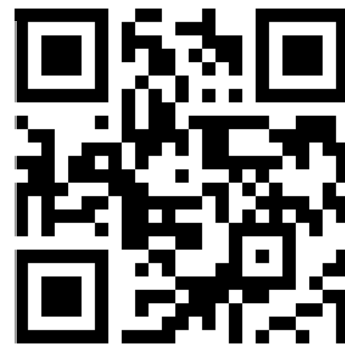
desktop



mobile



wearable



vision.plopes.org

?

what's next?

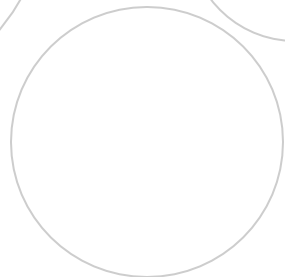
reflections: integration for a **different AI**



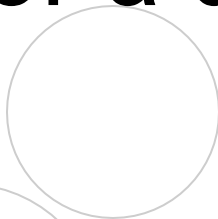
vision.plopes.org



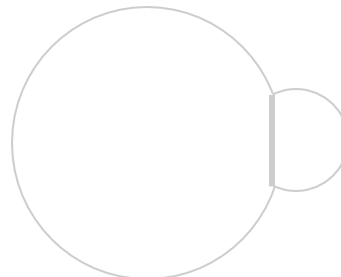
mainframe



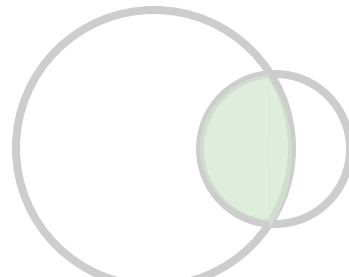
desktop



mobile



wearable



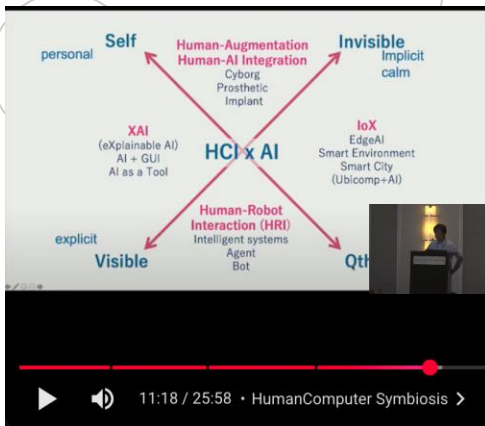
integrated

reflections: integration for a different AI

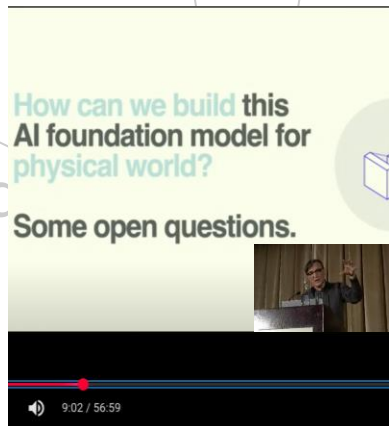


vision.plopes.org

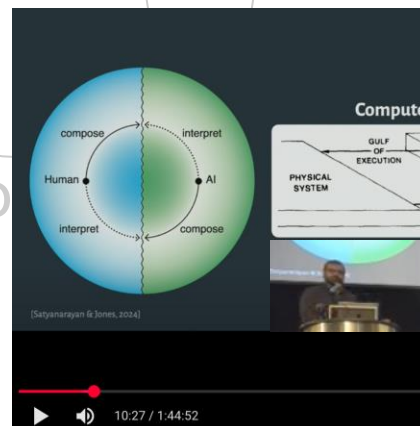
Rekimoto (2019): The Era of Human-AI Integration



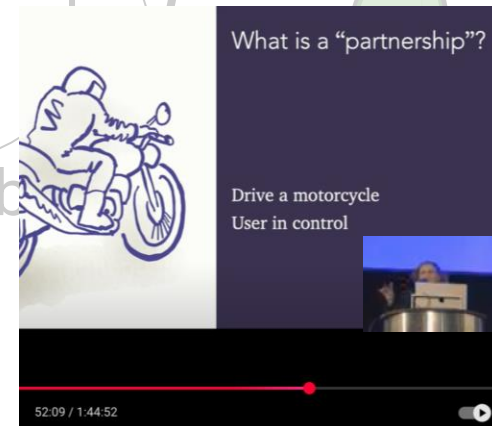
Poupyrev (2023): The Ultimate Interface



Satyanarayan (2024) Intelligence as Agency



Mackay (2024) Parasitic or Symbiotic?



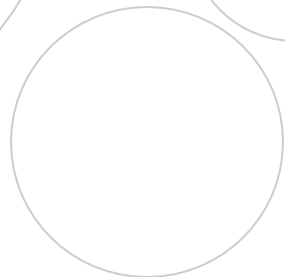
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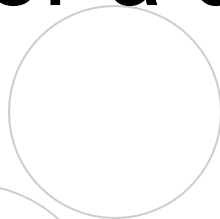
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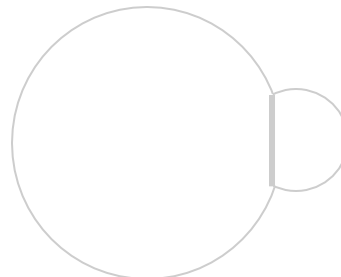
mainframe



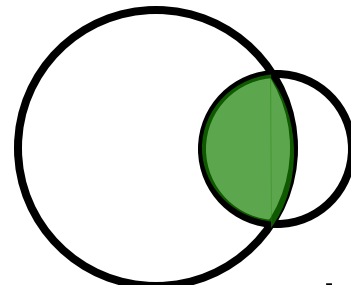
desktop



mobile



wearable



integrated

reflections: integration for a different AI

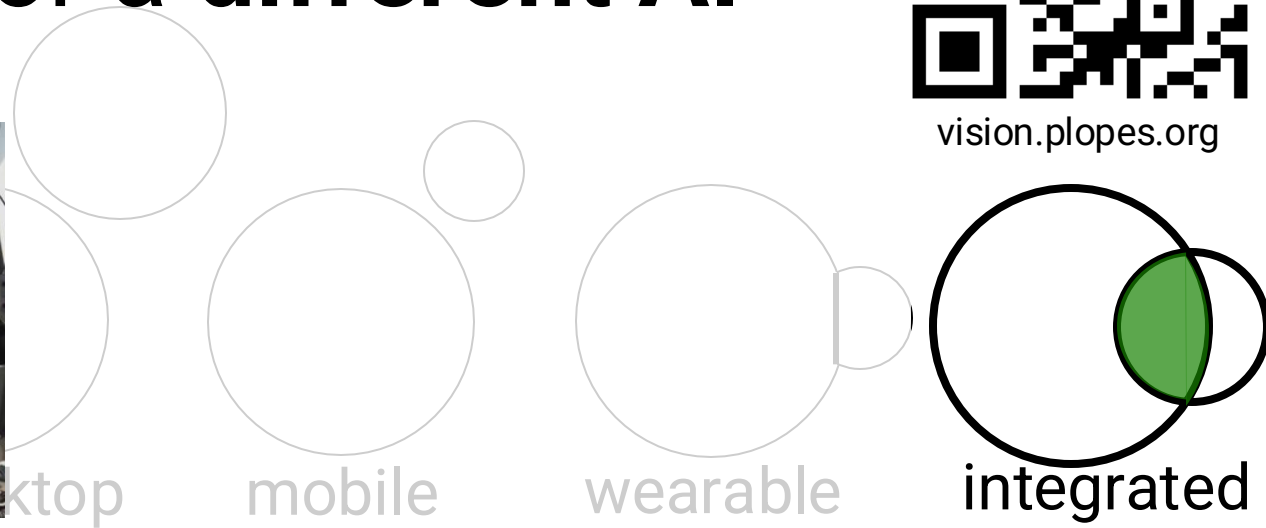


vision.plopes.org

Google deepmind, Gemini Robotics



robotic automation
for everything



reflections: integration for a different AI



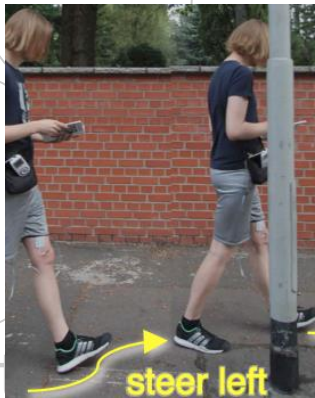
vision.plopes.org

Google deepmind, Gemini Robotics

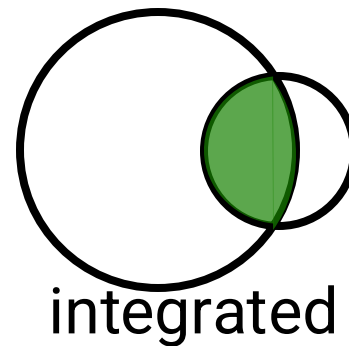
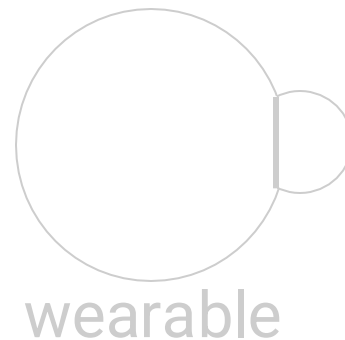


robotic automation
for everything

Pfeiffer et al., CHI'15



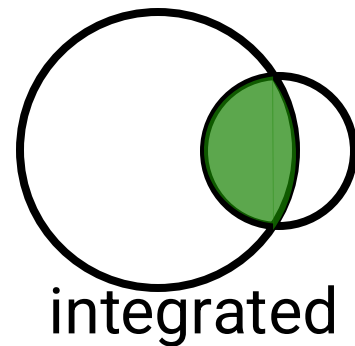
body automation
for safety



reflections: integration for a different AI



vision.plopes.org

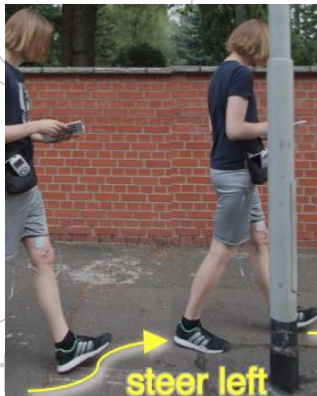


Google deepmind, Gemini Robotics



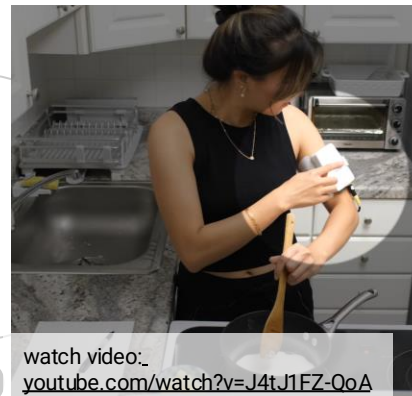
robotic automation
for everything

Pfeiffer et al., CHI'15



body automation
for safety

Nith et al., CHI'24

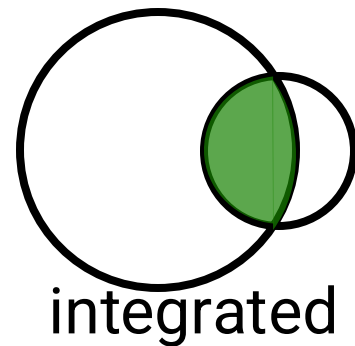


body automation
for repetitiveness

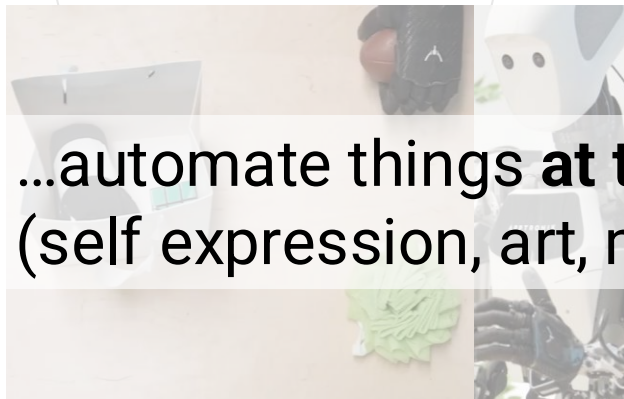
reflections: integration for a different AI



vision.plopes.org

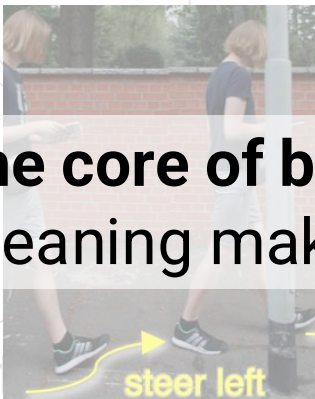


Google deepmind, Gemini Robotics



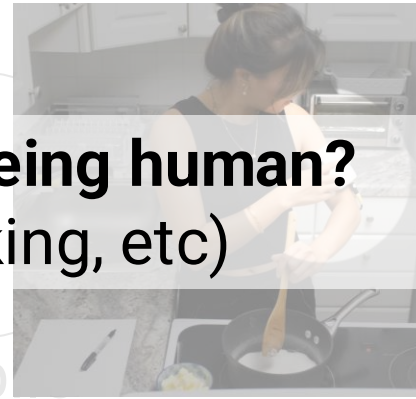
robotic automation
for everything

Pfeiffer et al., CHI'15



body automation
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Nith et al., CHI'24



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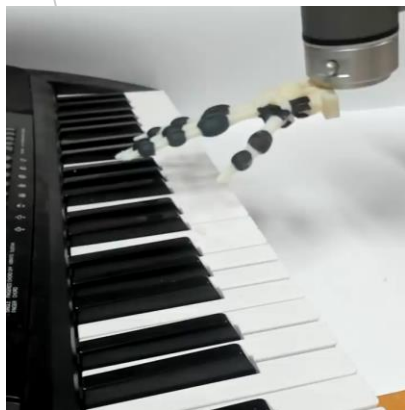
...automate things at the core of being human?
(self expression, art, meaning making, etc)

reflections: integration for a different AI



vision.plopes.org

Hughes et al., Science Robotics'18



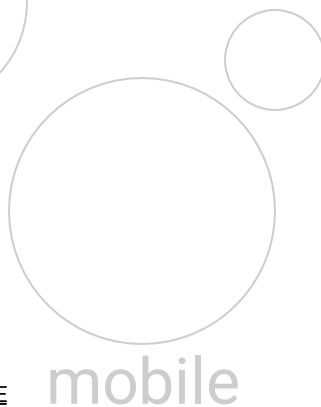
robotic automation
for everything

Choudhary et al., CHI'25



watch video:
[youtube.com/watch?v=VqgpRu2690E](https://www.youtube.com/watch?v=VqgpRu2690E)

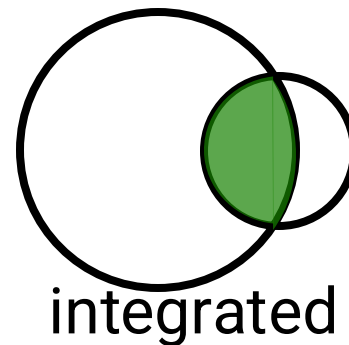
automation **of what**
makes us human?



mobile



wearable



integrated

reflections: integration for a different AI



vision.plopes.org

Hughes et al., Science Robotics'18



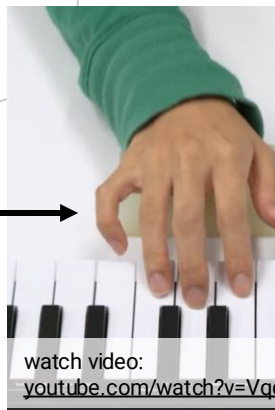
robotic automation
for everything

Choudhary et al., CHI'25



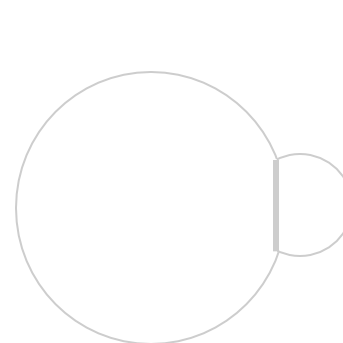
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Choudhary et al., CHI'25

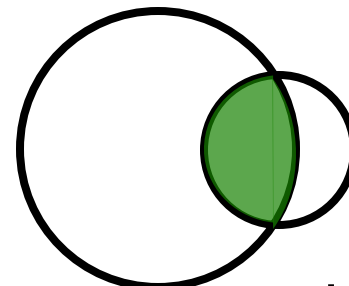


watch video:
[youtube.com/watch?v=VgqgRu269QE](https://www.youtube.com/watch?v=VgqgRu269QE)

body automation
for **learning**



wearable

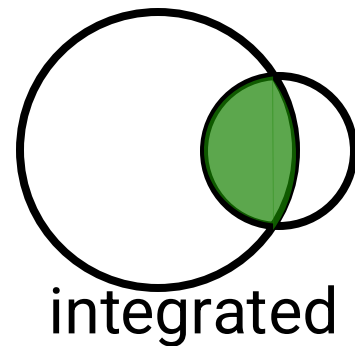


integrated

reflections: integration for a different AI



vision.plopes.org



integrated

Hughes et al., Science Robotics'18



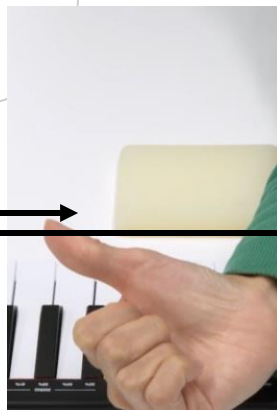
robotic automation
for everything

Choudhary et al., CHI'25



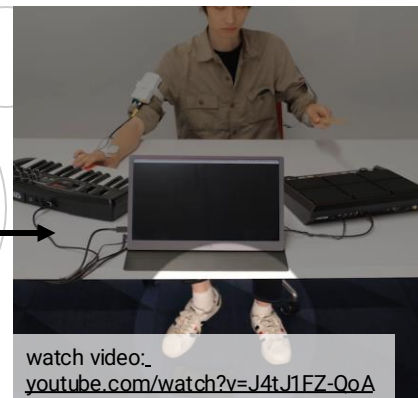
automation of what
makes us human?

Choudhary et al., CHI'25



body automation
for learning

Nith et al., CHI'24



watch video:
[youtube.com/watch?v=J4tJ1FZ-QoA](https://www.youtube.com/watch?v=J4tJ1FZ-QoA)

body automation
for new forms of art



vision.plopes.org

reflections: **other evolutionary routes?**



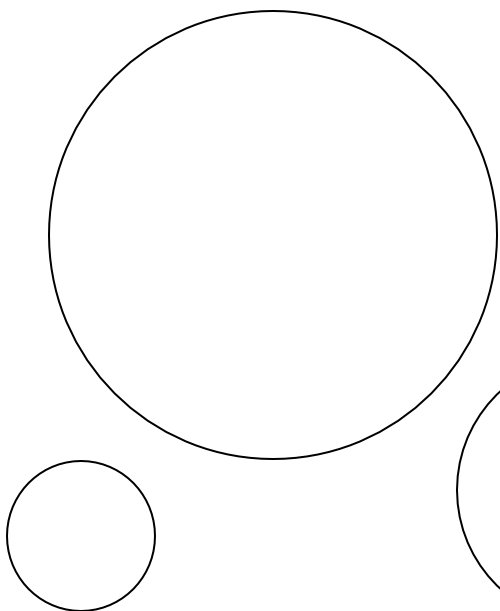
mainframe

desktop

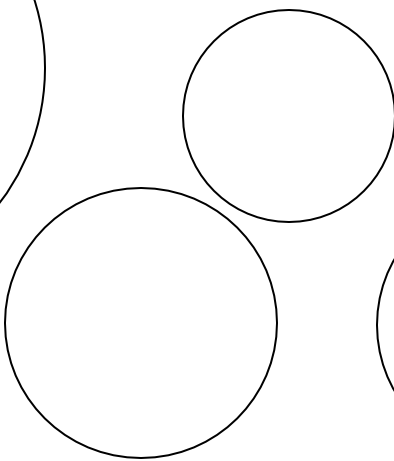
mobile

wearable

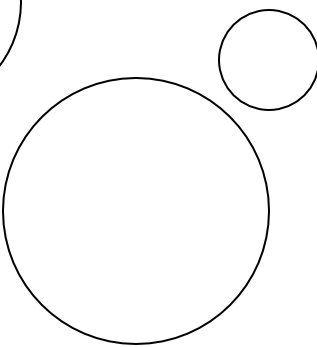
what's next?



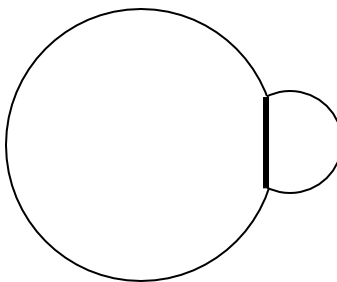
mainframe



desktop



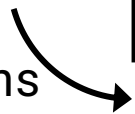
mobile



wearable



let's see
your
visions

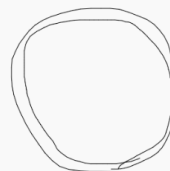
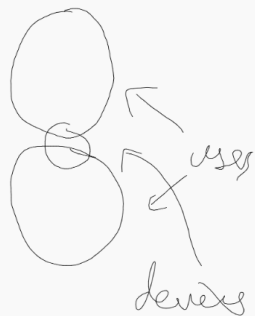
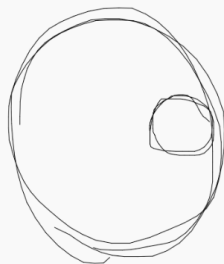
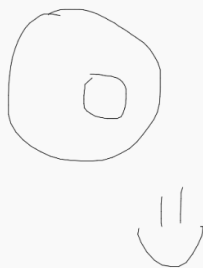


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?

what's next?

devices

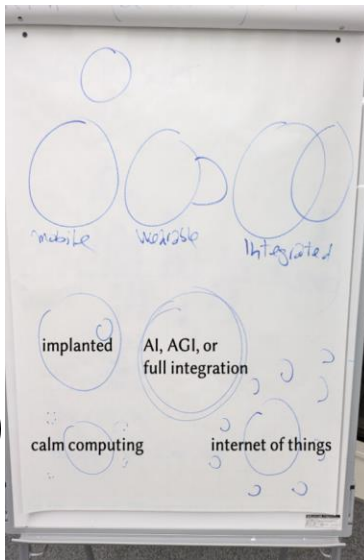
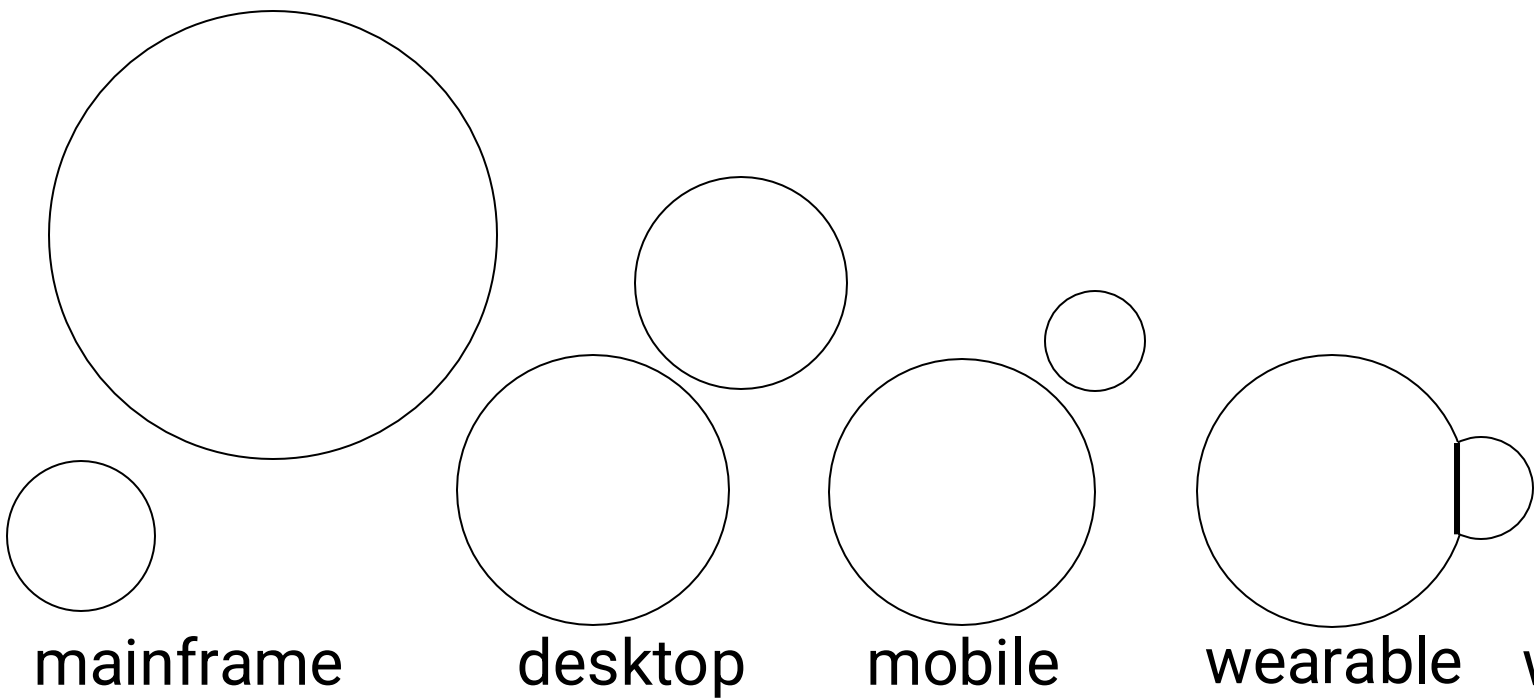


after the talk, I closed the website's ability to submit sketches
here are some of the 100+ submissions during the talk

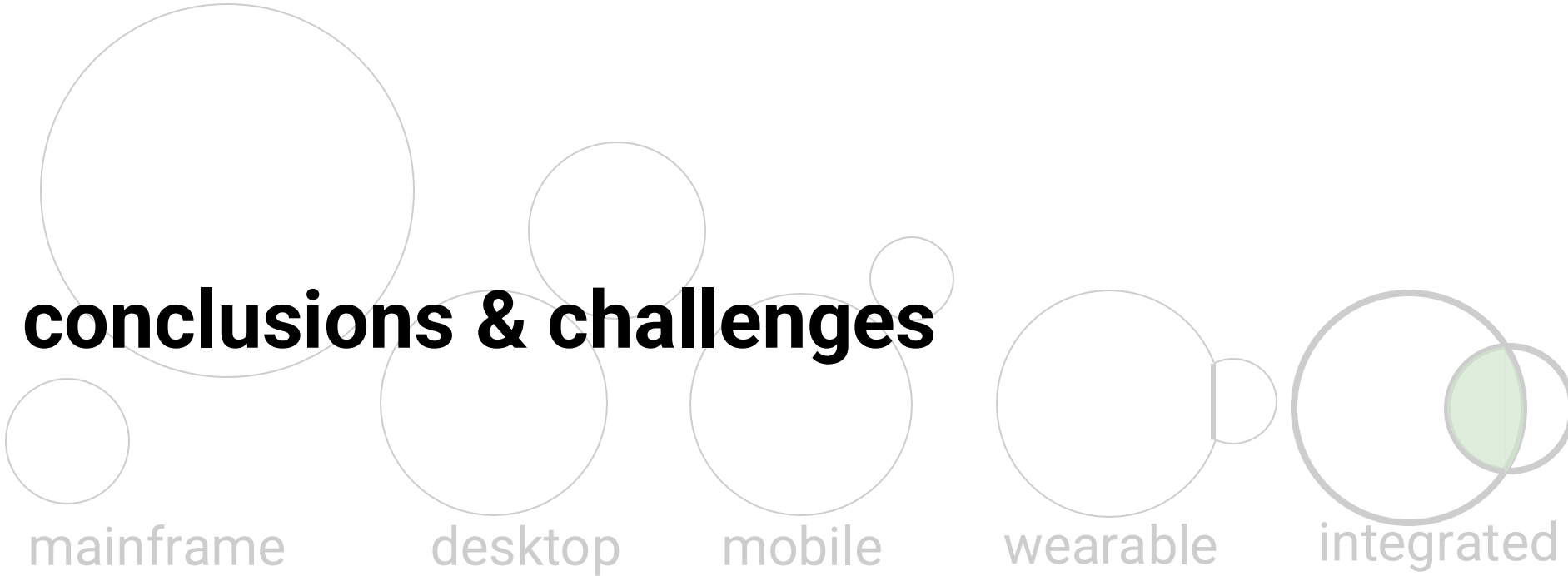


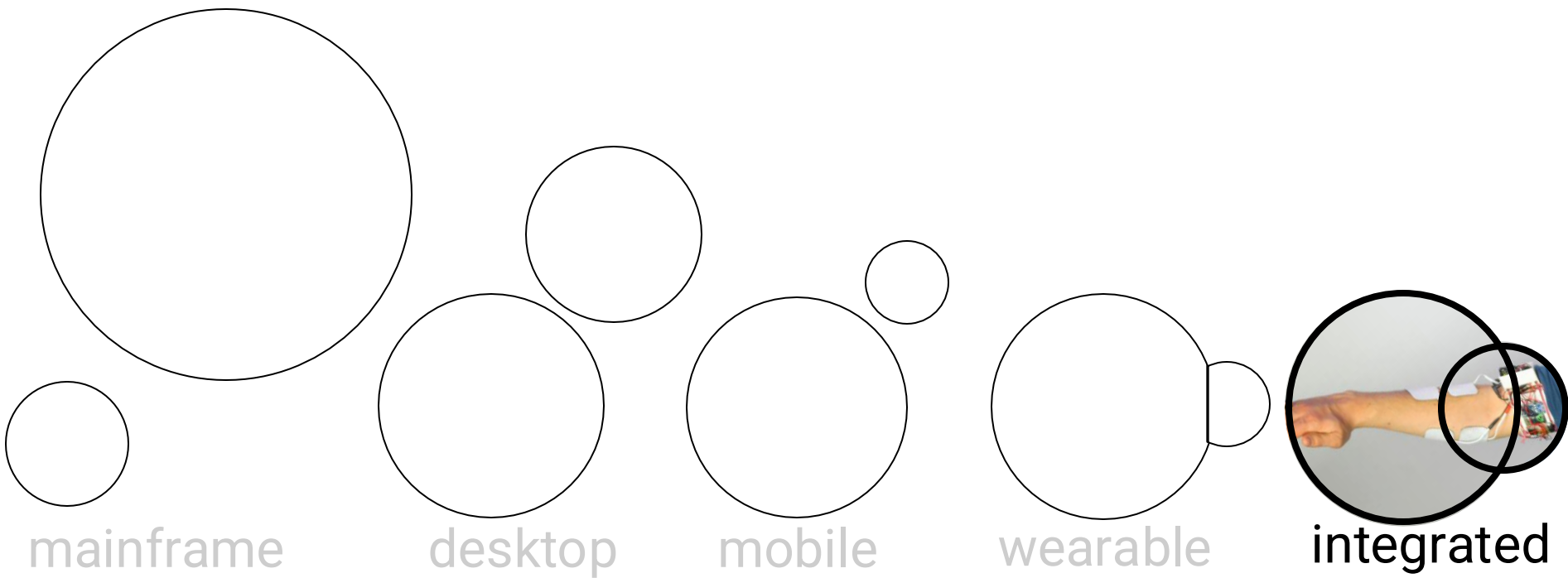
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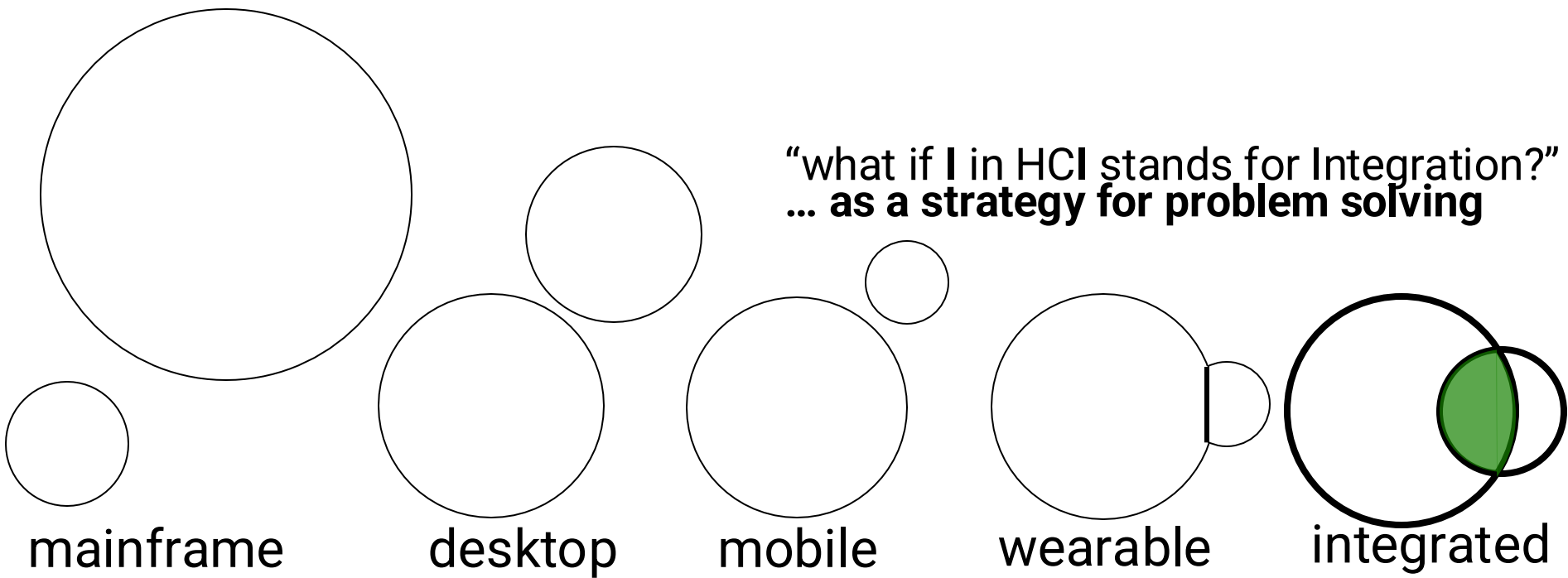




conclusions & challenges







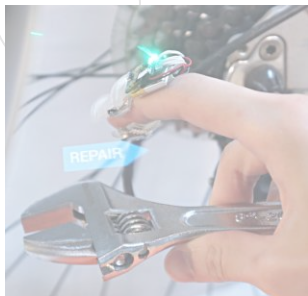


integrating distractions
UIST'22

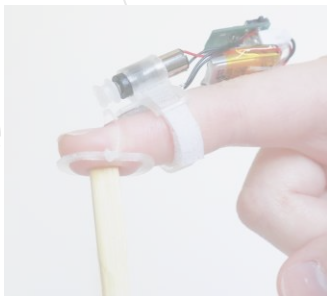


integrating organisms
UIST'22

**“what if I in HCI stands for Integration?”
... as a strategy for problem solving**



Touch & Fold CHI' 21



Alter Softness UIST'21



Back-of-Hand CHI'23



FeetThrough UIST'23



Stick&Slip CHI'24



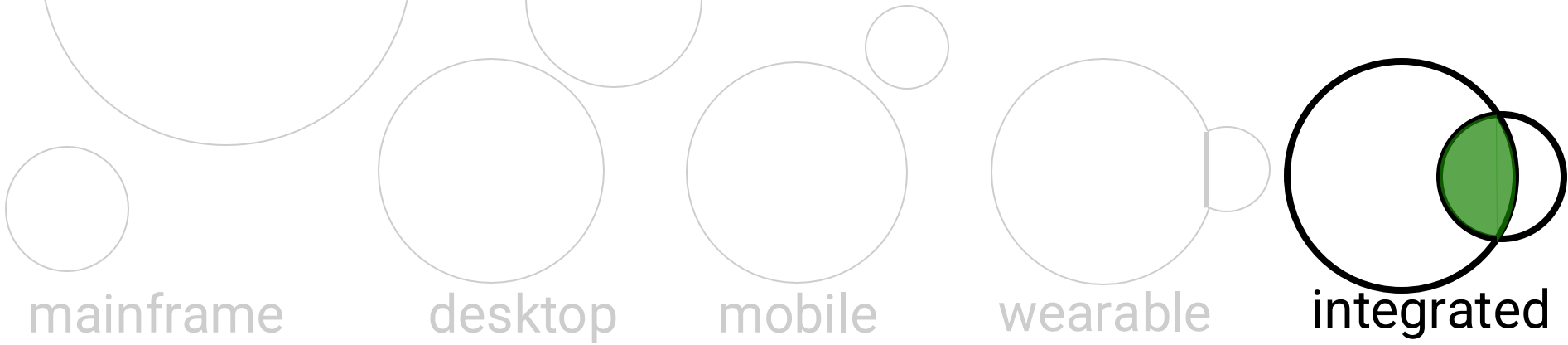
Permeability CHI' 24

integrating haptics with the real world



conclusions & challenges

do we **lose ourselves** if devices integrate?



conclusions & challenges

do we **lose ourselves** if devices integrate?

ethics

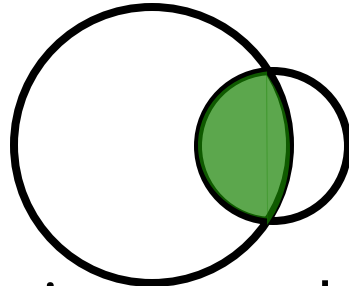
mainframe

desktop

mobile

wearable

integrated



conclusions & challenges

do we **lose ourselves** if devices integrate?

ethics

call for collaborative action

Ethics of the electrified mind: Defining principled use of brain stimulation in r
1. Emily L Evans², Roy H Hamilton^{2,3}

principled use of brain stimulation

[Laura Y Cabrera](#)¹, [Emily L Evans](#)², [Roy H Hamilton](#)^{2,3}

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PMCID: PMC3806889 NIHMSID: NIHMS488405 PMID: [23733](#)

Abstract

Abstract

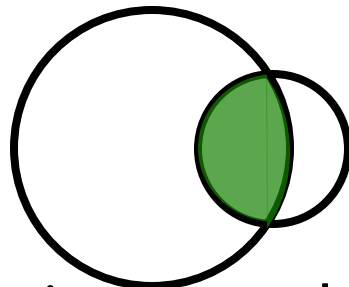
In recent years, non-pharmacologic approaches to the treatment of depression have gained increasing attention. One of these approaches is the use of electrical current, either the direct application of electrical current (ECT) or the indirect application of current by means of electrodes placed on the scalp (transcranial magnetic stimulation, TMS). Both ECT and TMS have generally been regarded as safe and effective treatments for depression. However, the mechanisms by which these treatments manipulate the brain have generally been regarded as unknown. The purpose of this review is to examine the mechanisms by which ECT and TMS manipulate the brain in depression-related conditions and the potential for these treatments to be used in the treatment of other conditions. The review will focus on the mechanisms by which ECT and TMS manipulate the brain and the potential for these treatments to be used in the treatment of other conditions.

desktop

mobile

wearable

integrated



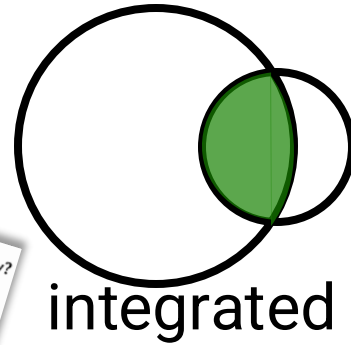
conclusions & challenges do we **lose ourselves** if devices integrate?

ethics

call for collaborative action

sense of agency

understanding sense of agency



Ethics of the electrified mind: Defining principled use of brain stimulation in research
Laura Y Cabrera¹, Emily L Evans², Roy H Hamilton^{2,3}

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PMCID: PMC3806889 NIHMSID: NIHMS488405 PMID: 23732

Abstract

In recent years, non-pharmacologic approaches to brain stimulation have gained increasing attention. One of these approaches is either the direct application of electrical current to the brain, or the indirect application of current by means of electrodes placed on the scalp. Both direct and indirect applications of current have generally been regarded as safe and effective. However, the potential for adverse effects on brain-related conditions and the capacity for long-term changes in brain function through brain stimulation are still poorly understood.

The experience of agency in human-computer interactions: a review

Hannah Limerick¹

¹ Department of Computer Science,
² Department of Psychology, Goldsmiths University of London
³ School of Experimental Psychology

The sense of agency is the feeling of being the author of one's actions. Although the sense of agency is often discussed in the context of 'real-life' situations, it is also a key concept in human-computer interaction.

The sense of agency in emerging human-computer integration

Patricia Cornelio^{1,2*} Patrick Haggard²
Joanna Bergström³ Sriram Subramanian¹

¹ Ultraleap Ltd., Bristol, United Kingdom
² Department of Computer Science, University College London
³ Department of Computer Science, University of Copenhagen

Human-computer integration is an emerging technology is blurred as users and computers interact. The sense of agency (SoA) is an experiential and sensory evidence whether the course of external events. The SoA is thus supporting a feeling of being integrated, wherein emerging technologies

How does HCI Understand Human Agency and Autonomy?
Daniel Bennett
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Aalto University
Espoo, Helsinki
Anne Roudaut
University of Bristol
Bristol, United Kingdom
Oussama Metatla
University of Bristol
Bristol, United Kingdom
Elisa D. Mekkler
IT University of Copenhagen
Copenhagen, Denmark

ABSTRACT

Human agency and autonomy have always been fundamental concepts in HCI. New developments, including ubiquitous AI and the increasing presence of technologies into our lives, make these concepts more relevant and complex. However, in HCI, there is no consensus on the meaning of agency and autonomy. Both concepts are used to address a wide range of phenomena pertaining to sense of control, material independence, and identity. It is unclear to what degree these concepts are compatible, and how they support the development of research programs and practical interventions. We address this by reviewing 30 years of HCI research on autonomy and agency to identify current understandings, open issues, and future directions. From this analysis, we identify ethical issues, and outline key themes to guide future work. We also articulate avenues for advancing clarity and specificity around these concepts, and for coordinating integrative work across different HCI communities.

CCS CONCEPTS

Human-centered computing → HCI theory, concepts and models.

KEYWORDS

Autonomy, agency, user experience, theory, delegation, self-determination, Theory, boundary objects, mixed initiative

ACM Reference Format:
Daniel Bennett, Oussama Metatla, Anne Roudaut, and Elisa D. Mekkler. 2022. How does HCI Understand Human Agency and Autonomy? In Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems, April 22–26, 2022, New York, NY, USA. ACM, New York, NY, 18 pages. <https://doi.org/10.1145/3526451>

users' sense of ownership over outcomes [37]. Development in recent years have only made these concepts more pertinent. In the context of HCI, agency and autonomy are often used interchangeably with intelligent systems [27], and the tight integration of technology into our lives and bodies [34, 122] all raise implications for human autonomy and agency.

As such, agency and autonomy stand out as potential boundary objects for HCI. Boundary objects are constructs which support roles across multiple objects are constructs which coordinate the perspectives of these communities [100].

shared problem definitions, and generating robust knowledge without relying on strict consensus [103]. At the same time, they support negotiation of their identities across communities in HCI, their belonging back to the concepts of agency and autonomy, and their balance with responsibility and importance of agency and autonomy.

conclusions & challenges

do we **lose ourselves** if devices integrate?

ethics

call for collaborative action

Ethics of the electrified mind: Defining principled use of brain stimulation in research

Laura Y Cabrera¹, Emily L Evans², Roy H Hamilton^{2,3}

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PMCID: PMC3806889 NIHMSID: NIHMS488405 PMID: 23733

Abstract

In recent years, non-pharmacologic approaches to brain stimulation have gained increasing attention. One of these approaches is transcranial magnetic stimulation (TMS), either the direct application of electrical current to the brain or the indirect application of current by means of electrical coils. Indirect application of current by means of electrical coils to manipulate the brain have generally been regarded as safe, but the brain-related conditions and the capacity to manipulate the brain through brain stimulation are still under investigation.

sense of agency

designing for agency in integration

I did it!



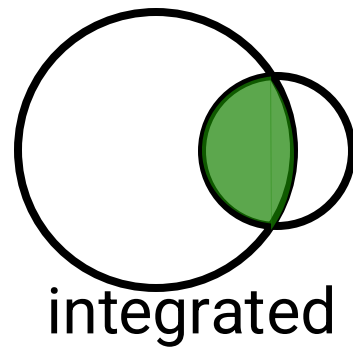
agency
tradeoffs

CHI'19
TOCHI'21



agency neural
mechanisms

Cortex'19
JNeuro'23
Jneuro'25



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Ethics of the electrified mind: Defining principled use of brain stimulation in research

Laura Y Cabrera¹, Emily L Evans², Roy H Hamilton^{2,3}

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Abstract

In recent years, non-pharmacologic approaches to brain stimulation have gained increasing attention. One of these approaches is either the direct application of electrical current to the brain or indirect application of current by means of electrical stimulation of peripheral nerves. Both direct and indirect application of current to the brain have generally been regarded as safe and effective. However, the potential for adverse effects on the brain and the potential for abuse of brain stimulation technology have raised concerns.

sense of agency

designing for agency in integration

I did it!



agency
tradeoffs

CHI'19
TOCHI'21

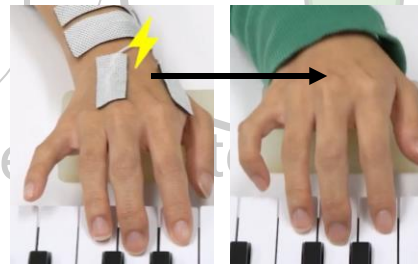


agency neural
mechanisms

Cortex'19
JNeuro'23
Jneuro'25

dependency

design for absence



aim for **learning**
not replacing us

CHI'21
CHI'25

acknowledgements

our team



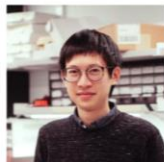
Pedro Lopes (CV)
Assoc. Prof.



Yun Ho
PhD student



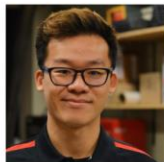
Dr. Jas Brooks
PhD -> Prof. MIT ✈️



Dr. Shan-Yuan Teng
PhD -> Prof. NTU ✈️



Jasmine Lu
PhD student



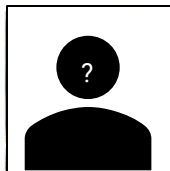
Romain Nith
PhD Student



Yudai Tanaka
PhD Student



Lonnie Chien
PreDoc



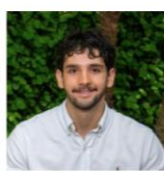
you!
come work with us
all positions



Mithil Guru
Collaborator



Haley Breslin
Ugrad



Andre De La Cruz
Ugrad

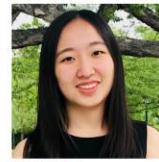
human computer integration lab



some of our alumni



Jun Nishida
Postdoc 2019-22
Now: Prof. UMaryland



Yujie Tao
Master 2021-22
Now: Stanford PhD



Alex Mazursky
PhD student
Now: Apple Engineer



Joyce Passananti
Ugrad Spring 2022
Now: UCSB PhD



Arata Jingu
Intern Winter 2022
Now: Saarland PhD



Siya Choudhary
Highschooler
Now: UIUC

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thanks for your attention, questions?

what if the “I” in HCI
stands for Integration?

pedro lopes

associate prof. in computer science



slides:

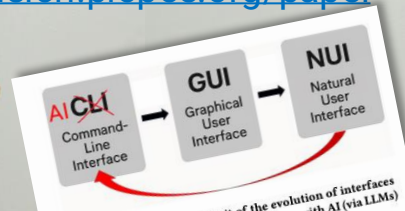
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see the sketches from
the UIST audience

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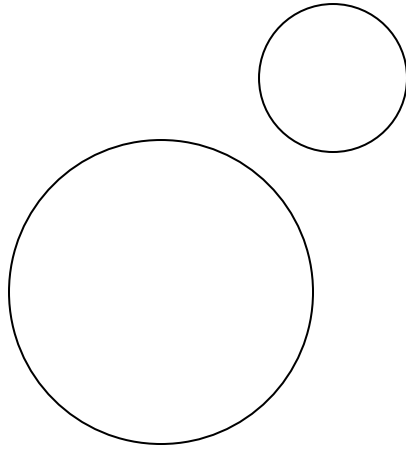
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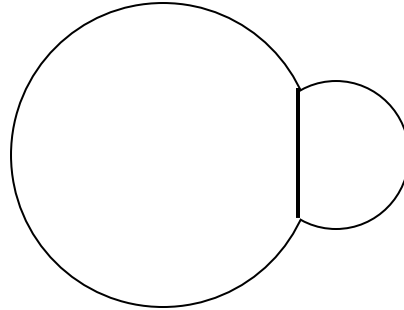


agency ✓

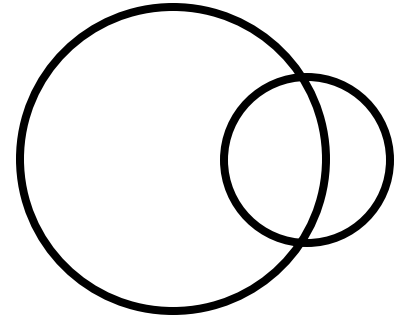
agency ✗



mobile



wearable



integrated
with body

<https://www.youtube.com/watch?v=UsL48gkh3GI>

ethical implications of EMS



patrick baudisch
HPI



Ars Electronica 2017



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by pedro lopes / doga yueksel / patrick baudisch

photos of parasite (ad infinitum) art work

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