PneuMa: Designing Pneumatic Bodily Extensions for Supporting Movement in Everyday Life

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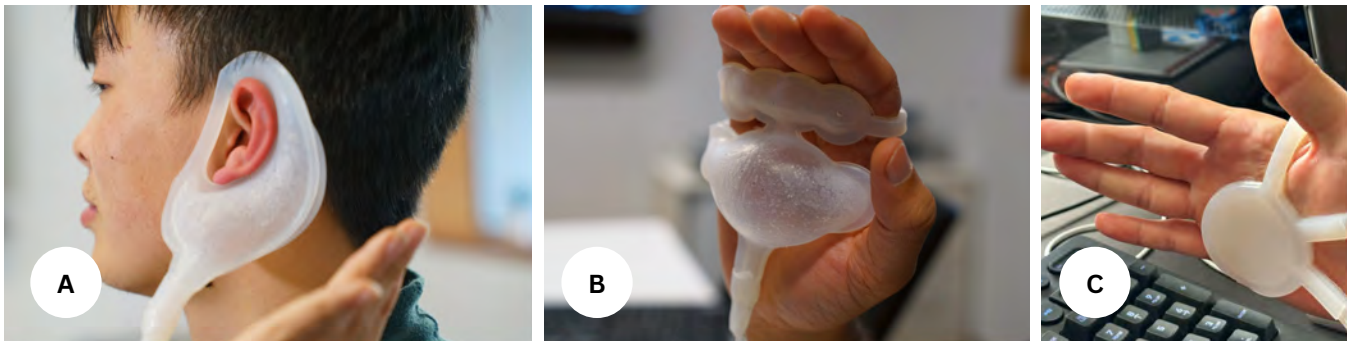

Figure 1: PneuMa Bodily Extensions: A) "Pardon", B) "Greetings", and C) "Take a break".

ABSTRACT

Prior research around the design of interactive systems has highlighted the benefits of supporting embodiment in everyday life. This resulted in the creation of body-centric systems that leverage movement. However, these advances supporting movement in everyday life, aligning with the embodiment theory, so far focused on sensing movement as opposed to facilitating movement. We present PneuMa, a novel wearable system that can facilitate movement in everyday life through pneumatic-based bodily extensions. We showcase the system through three examples: "Pardon?", moving the ear forward; "Greetings", moving a hand towards the "Bye-bye" gesture; "Take a break", moving the hands away from the keyboard, enabling the bodily extensions that support movement in everyday life. We delve into some findings in relation to prior research around bodily extensions and embodied interaction in the video. Ultimately, we hope that our work helps more people profit from the benefits of everyday movement support.

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CCS CONCEPTS

• **Human-centered computing** → *Human computer interaction (HCI)*; Interaction paradigms;

KEYWORDS

bodily extensions, pneumatics, embodied interactions, embodied experiences

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1 INTRODUCTION

The theory of embodied interaction has been explored extensively by several researchers to offer a wide range of applications [8, 13, 36]. Supporting embodiment in everyday life has been credited with tangible benefits for its users, such as speech production, memory

recall, and temporal perception [5–7, 26]. Owing to these associated contributions, wearables that sense movements for users in everyday life have become prevalent in HCI research [1, 12, 33, 37]. Although these advancements have been primarily focused towards sensing and feedback, there have been some explorations that function as an addition to the human body to facilitate novel experiences [2, 15]. The additions to the human body that physically alter or extend the structure of the body have been called "Bodily Extensions" [3, 19]. Bodily extensions offer a myriad of solutions ranging from accessibility [40], targeted feedback [31], motor functionality [38], or allowing super-normal capability [32].

Along with supporting embodiment, prior work has explored bodily extensions through a variety of lenses. Buruk et al. presented a series of bodily extensions through a phenomenological lens to explore the experiential aspects of using them [3]. Research efforts around both wearables and bodily extensions have been focused towards sensing movements [10, 24, 39]. However, both wearables and bodily extensions that induce movement while also extending the body have been sparingly explored.

Shape-changing wearables and bodily extensions have been proposed in several contexts, including novel interactions [11], virtual reality [35], accessibility [40], and games [34]. However, these systems have been focused on delivering assistance during specific tasks or delivering contextual feedback to the user engaged in a digital experience. Taken together, they miss the opportunity to facilitate an experience where the user moves the body as the eventual interaction, as learned from the embodiment theory. While there has been a recent interest in HCI to create applications that facilitate bodily movement (actuation), the means have been intrusive or have possessed an uncomfortable amount of weight to be wearable (bulky) [14]. Bodily actuation applications, primarily manifested through VR [35], force feedback [17, 18], and games [16, 20, 22, 23, 25] miss out on the opportunity to facilitate an embodied experience which in turn has the potential to increase awareness [13] and various other cognitive abilities [4–6, 21]. As a result, the roles of these technologies have been limited in the scope of everyday life and majorly reduced to short novel interactions owing to their issues with wearability, comfort and body conformity.

1.1 The PneuMa System

As highlighted by prior research, facilitating bodily movement in everyday life scenarios promotes embodiment [9]. Supporting embodiment through movement further leads to improvement in cognitive abilities as it associates sensorimotor feedback with the mind [13, 21]. Therefore, we present PneuMa, a novel wearable system for pneumatic-based bodily extensions to support movement in everyday life. We showcase the system through three examples: "Pardon?", moving the ear forward; "Greetings", moving a hand towards the "Bye-bye" gesture; "Take a break", moving the hands away from the keyboard. As we want to support "everyday life", i.e. enable users to wear the bodily extensions comfortably on their body while not restricting other movements [30], we leverage the soft material feel of silicone to create bodily extensions that support movement in everyday life. We borrow the term "bodily extensions" from Buruk et al.'s work [3], as our wearables, while facilitating bodily movement, also physically alter or extend the structure of the human body [27–29]. In this paper, we demonstrate our system through two different inputs, speech and an automated timer (user configurable), to support bodily movement. We implemented three unique bodily extensions aiming to support the following scenarios in everyday life:

- Pardon?: Promoting a good-bye gesture by moving the user's hand towards such a gesture if the system senses the words "good-bye" (through a smartphone's microphone).
- Greetings: Moving a user's ear forward and enlarging it whenever the system senses the words "Beg your pardon?"
- Take a break: Moving the user's hands away from the keyboard in order to encourage a break from typing.

For further design and field study details please refer to our TEI'24 paper [28].

2 CONCLUSION

In this paper, we presented PneuMa, a pneumatic-based wearable system for silicone-based bodily extensions to support movement in everyday life. Using our system helped the users become more aware of their bodies and highlighted for them the importance of bodily movement in certain scenarios. In the accompanying video, we highlighted the importance of movement in everyday life along with the possible benefits of our system PneuMa in three scenarios. We hope that our work extends and creates knowledge for exploring the area of bodily extensions for embodiment. We hope that our work helps people profit from the benefits of embodiment support.

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