

# Embodied learning and play in sensorimotor augmentations for kids

**Stefania Druga**

Lifelong Kindergarten Lab  
MIT Media Lab  
Cambridge, MA 02142, USA  
sdruga@mit.edu

## Abstract

New forms of programmable body augmentations and supporting technologies can be designed to enable the way children develop intelligence in the world through play and exploration. In order to design programmable kids body extensions designers must understand how children interact with the world and understand the representations embedded in tangible systems. In this short paper, the author is reviewing relevant theory from cognitive developmental psychology and existing projects for body extension in order to propose new applications for embodied learning and play.

## Author Keywords

Tangible interactions, body augmentation, cognitive development learning, children.

## ACM Classification Keywords

H.5.2. [Information Interfaces and Presentation]: User interfaces, H.5.1 [Multimedia Information Systems]:

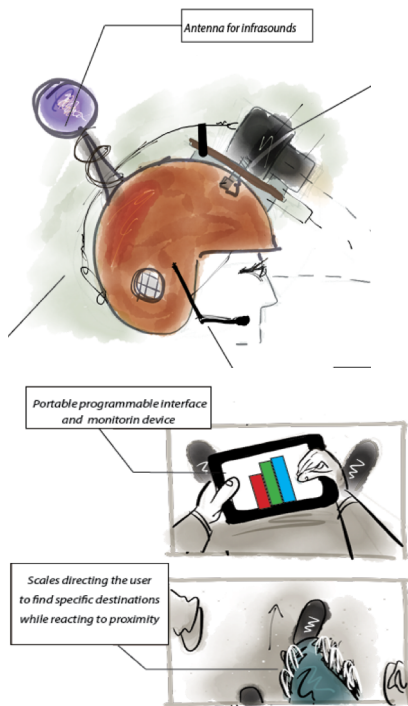


Fig 1. Design scenarios where kids could repurpose their helmets or clothes to attach extensions that could augment their sense while programming these extensions to classify external information and communicate with other extensions.

Artificial, augmented and virtual realities.

## Introduction

While computational thinking is a priority both on the agenda of educators, corporate funders and policy makers, I am wondering how it's proposition could be expanded to enable young people to learn not only how to code but also design and build programmable body extensions that can enable them to interact with the world in different ways while extending their sensing capabilities. Healy provides support for physically-based forms of child computer interaction when she states that body movements, the ability to touch, feel, manipulate and build sensory awareness of the relationships in the world is crucial to children's cognitive development [1]. This paper presents a series of theoretically grounded design considerations and examples of current prototypes and design scenarios of responsive sensorimotor body extensions for children.

## Embodied cognition

Embodied cognitive science argues that human ability to reason is based on our ability to perceive, manipulate objects, orient ourselves and move through

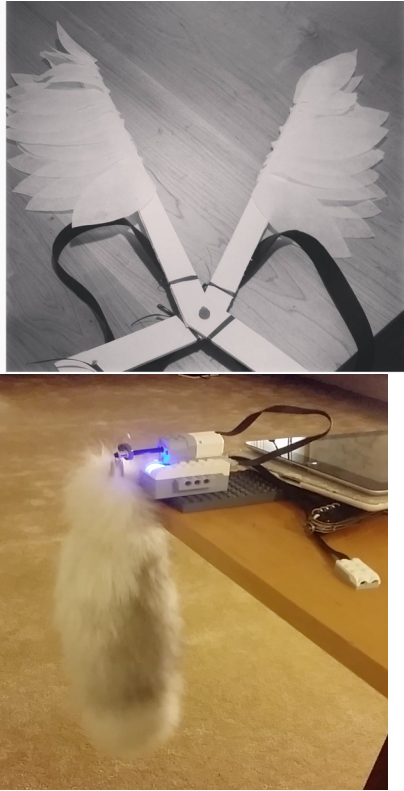


Fig 2. Prototypes of animatronic wings and tail that can be programmed with Scratch Extensions ([scratchx.org](http://scratchx.org)) and Lego Wedo2 to react to the environment (light, distance, tilt, sound).

space [2]. By accumulating various body experiences children develop new ways of making sense of the world through a combination of sensation, perception, action and reflection. For example, children often learn to measure using their body as a reference or to count by using their fingers. Furthermore, when students talk about mathematical concepts they are learning, they often express new knowledge in gestures before they express it in speech [3]. The relationship of action and cognition is made salient by an example from Papert, [4] who shows in his work with turtle geometry and Logo that a student could understand, predict and reason about the turtle's motion by imagining what they would do if they were the turtle. He coins this ability as "body syntonic" reasoning and shows how powerful it is to create metaphors that enable kids to embody problem solving and portray themselves in the learning scenario. Inspired by these findings I wanted to enhance children natural gestures and movements with a series of body extensions and augmentations that will enable them to gather additional sensory and spatial information while interacting naturally with the world around them.

### Spatial reasoning

Spatial cognition concerns the study of knowledge and beliefs about spatial properties of objects and events in the world. Spatial properties include location, size, distance, direction, separation and connection, shape, pattern, and movement. Spatial schemata<sup>1</sup> provides a foundation for more abstract reasoning because their familiar organizational structures can be used to

<sup>1</sup> Organized knowledge structures that are acquired in the process of cognitive development.

facilitate memory, communication and reasoning [5]. While some of these mechanisms are debated, it is clear that children use rich spatial schemata for the development of more abstract schemata. For example, children are often taught counting using physical manipulatives [6] or by referring to spatial metaphors (e.g. adding objects in a pile). Another important aspect to consider is that early motor and spatial training may result in positive long-term effects in other areas of cognitive development [7].

Concepts from embodied cognition and spatial reasoning suggest that successful tangible systems will incorporate an adaptive, body-based style of interaction which leverages children's developing and existing repertoire of physically-based actions. Acquisition of knowledge will be achieved through exploration with real time feedback of how things work. This perspective has implications for learning and instruction across the range of content areas.

### Embodied play and programmable body extensions: current prototypes and future design scenarios

Based on the of theoretically grounded design considerations that take into account both kids embodied and spatial cognition I designed a series of prototypes of body extensions such as mechatronic wings and tail and responsive necklaces (fig 2). An important design consideration was to make these body extensions modular and programable as I would like to enable the children to constantly tinker with them either via voice commands or tangible monitoring and programming on mobile devices.

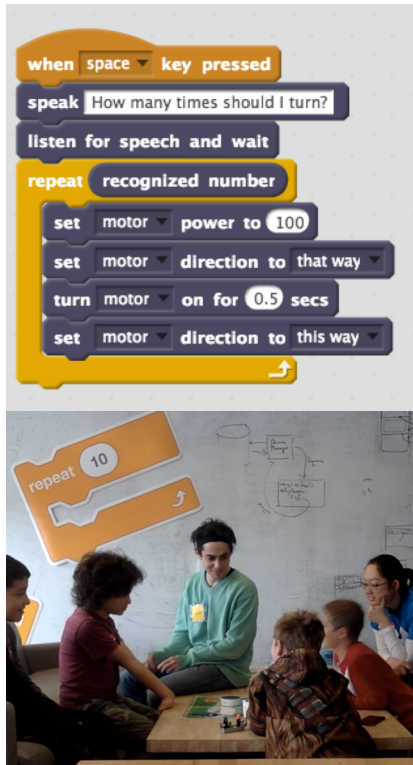


Fig 3. Example program created with Scratch Extensions[8] used to make the tailand wings react to music and speech.

Fig 4. Picture from playtest Randi Williams and the author organized with 45 kids in Lifelong Kindergarten Group on 03.18.2017 in order to observe interactions with various smart toys and bots.

For programming, I am using Scratch 3.0 and Scratch Extensions, a visual programming environment developed by the Lifelong Kindergarten Group at the MIT Media Lab. This intuitive visual programming environment that can easily interface with physical and digital inputs and outputs such as sensors, servos and various web applications such as natural language processing engines or music streaming. In fig 3 there is an example of the Scratch program I am using in order to control the tail motions via voice and to make it dance in rhythm with any song from Spotify.

These sensorimotor extensions start with very simple mechanism composed of a single servo motor and a Lego Wedo2 brick which can connect to any tablet, phone or computer via Bluetooth. With the approach of low floors and wide walls [9] I am preparing simple templates of programs in scratch that showcase the possibilities of interactions such as reacting to voice commands, sensor inputs or web data such as music beats or tweets. On the physical side the second iteration of the body extensions will be modular which would allow the children to add degrees of freedom and increased expressivity to their body extensions and to customize in different contexts.

In a recent playtest (fig 4) I organized in Lifelong Kindergarten with 45 children I observed that they prefer to use voice commands when interacting with robots or smart toys such as Cayla or bots such as Alexa. This experience let me to imagine a new way for kids to interact and learn with their body extensions via situated “conversational programming” and learning.

Children cognitive development may be understood in terms of interactions of multiple local factors such as: bodily growth, environmental factors, brain maturation and learning. Clarke calls this approach to systems design “soft assembly” and defines it in contrast to systems with centralized control [9]. This cognitive development requires the ability to perturb a system, explore assumptions and revise thinking based on feedback [10].

In order to facilitate this kind of learning I envision a system of modular programmable tangibles that kids could tinker with, both physically and digitally, to create their own body augmentation. These playful soft assembly systems could use tangible objects as a memory aid or provide what Resnick calls “conceptual leverage” which enables children to learn concepts and develop schemata which mirrors their learning “in the wild” [11].

I am also envisioning that these sensorimotor body extensions will become more and more augmentations that could enable children to sense things that we cannot currently perceive such as infrasound or radio signals while developing new aesthetics, ways of communicating and learning while encouraging and enabling personal expression and identity building.

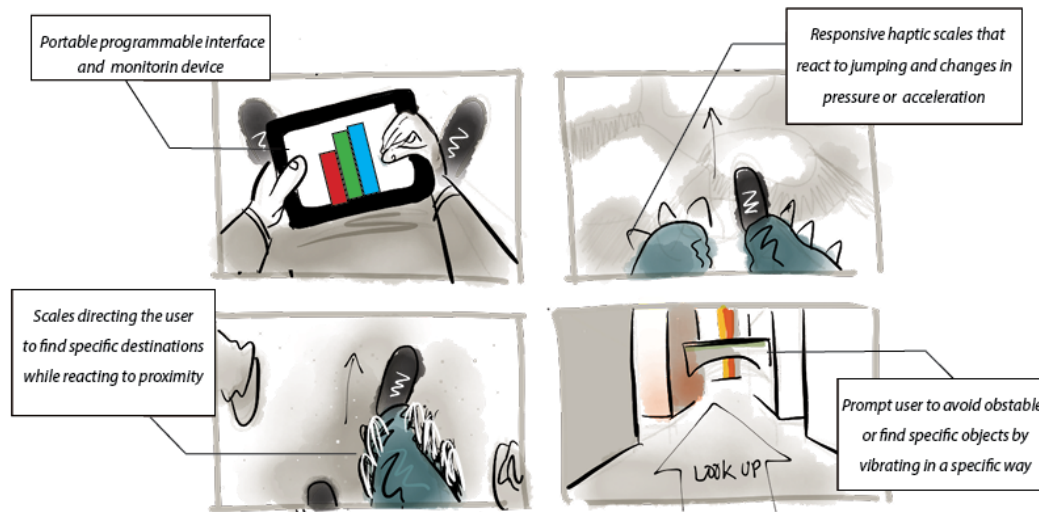


Fig 5: Design scenario for a pair of pants that have responsive scales which can be used in mapping games or for measuring different body signals such as speed, proximity, position

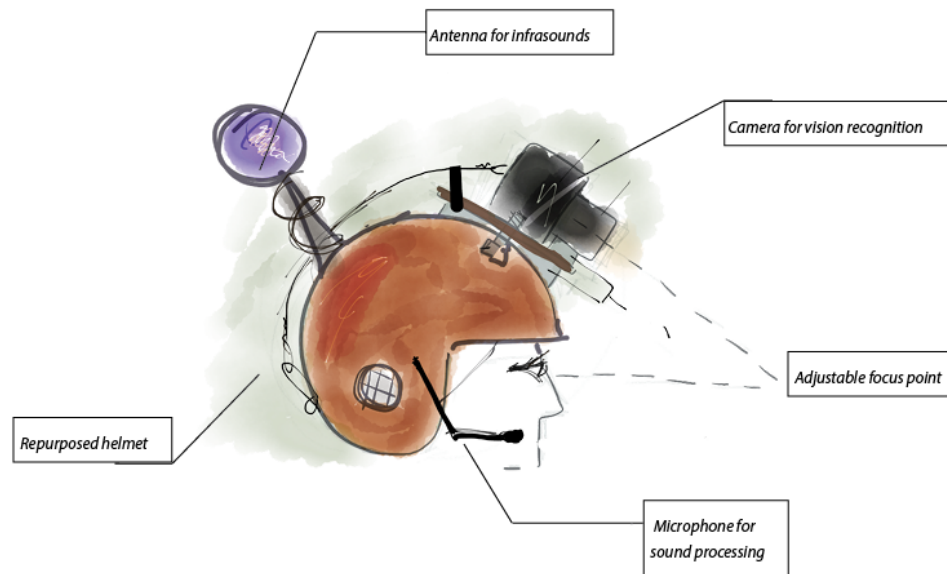


Fig 6. Children could repurpose their bike or skating helmets and attach gradually extension that could augment their senses. These modular extensions could sense things we cannot observe such as infrared sounds and they could be programmed to make classifications of outside information and communicate with other extensions from the same user or other users

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