From Inaction to Interaction: Concept and Application of the Null Gesture

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Figure 1: A meaningless movement (finger tap on cheek, red arrow) is given meaning in the human-computer dialogue.

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Abstract

Gestures in HCI often have a meaning in the real world or are specifically designed for an application. They have a definition and purpose. We introduce Null Gestures: Bodily utterances that have no clearly defined purpose or meaning, such as rubbing one's chin while thinking. They exist, but their assignment is “Null”. Using the computer, we help users unlock their potential by giving them a meaning in the human-computer dialogue. We thus hope to instigate a discussion about their potential use in HCI and the role of the computer as an enabler for the discovery of unused motor abilities.

Author Keywords

Idle; Gestures; Meaning; Embodied; MYO; EMG Input

ACM Classification Keywords

H.5.2 [Information interfaces and presentation (e.g., HCI)]: User Interfaces – Input devices and strategies

Introduction

Modern HCI employs a plethora of input techniques, such as touch [5], speech [17], and gestures with [3] or on the body [16]. In addition to this “active” input, researchers monitor body signals and context [26]. Thus generated “passive” input can be used to detect frustration and sup-

Gesture	Count
Rest head or cheek on hand	**10**
Rub chin	**8**
Tap foot or move leg	7
Tap finger on face, arm or surface	**7**
Crossed arms	**5**
Look around	5
Walk around	4
Scratch head	4
Bite lip	3
Scratch ear	3
Bite fingers	2
Tap hand on leg	2

Table 1: The accumulated 12 most frequent observations and responses from 15 users. Users sometimes performed multiple gestures and gave multiple answers, but a certain observation or response was only noted once per user. The gestures explored in this paper are printed in **bold**.

port users when using a GUI [32] or to adapt the tempo of a song to their running speed [14].

Looking at the philosophy of gesture and speech-based approaches, it seems that many aim to follow Dourish's concept of "embodied interaction", which is described as the "creation, manipulation, and sharing of meaning through engaged interaction with artifacts" [11, p. 126]. An [inter]action may hold and create meaning and value that is linked to the sociocultural background of the user, which may have prompted Jacob et al. [19] to define the framework of Reality-Based Interaction (RBI) for HCI: The use of actions that are either in the real world or "like the real world" [19]. Interaction techniques corresponding to this framework are supposed to be easy to understand and execute in the human-machine dialogue due to their meaning and definition in real life.

Following this concept, gesture-based input techniques seem to have a crucial characteristic: They either have a sociocultural meaning that is transferred to the domain of HCI [19], or they are specifically designed for a certain purpose that may not have a real-world counterpart, but which exists in the human-computer dialogue nonetheless and therefore has a specific meaning to the user, such as the pinch-to-zoom gesture [21]. With regards to instruments, a meaning can be so strongly associated with an action that it may even be found out by "reverse-engineering" its sound into a bodily expression, as examined in the concept of sonic affordances [31, 7]. Most importantly though, a user may have to take up a certain position and be in an "active" state that allows them to perform these consciously chosen, meaningful, and purposeful gestures like pointing [3], tilting and flicking [12], or moving the whole body [23].

Definition and Motivation

Contrary to the strategy of using purposefully designed or culturally defined actions for HCI, we would like to propose a different approach: Using bodily expressions that appear to be undirected actions, performed without tangible objects and employing the computer to allow the user to give meaning to the previously meaningless. For example: When people are bored, waiting or thinking, they often (unconsciously) perform actions such as tapping their feet or fingers, rubbing their chin or scratching their head (Tab.1). Such undirected actions may be interpreted as displacement activities [9] or, in the animal world, as vacuum activities [13], where actions are performed without the presence of an inducing stimulus or contextual purpose. In a human context, these muscular "utterances" could be the result of the thinking process, meaning that while we contemplate a problem, neural networks may be queried and as a result, certain muscular actions may be performed on a low scale to either simulate or evaluate a situation [6]. This observation may have led others to interpret such movements as a means to aid concentration [28].

Definition

Whatever the reason for these movements' occurrence, they appear to "emerge" from a certain body stance or state of mind, be it boredom or concentration, and largely appear undirected. We propose that these "emerging" actions do neither have a defined purpose, nor a clear culturally assigned meaning (apart from signalling boredom or concentration), as so many other actions in our communication via our limbs. Their functional "assignment" is blank. Speaking in terms of programming, their functional assignment is "Null", leading us to propose the term "**Null Gestures**" (NGs) for these emerging gestures.

Figure 2: NG1: The user rests their head on their hand and taps it with index or middle finger.

Figure 3: NG2: The user rests their head on their hand and extends and holds index or middle finger.

Motivation and structure
As stated in the introduction, gestures used for HCI may either have a function defined by one's sociocultural background and circumstances or are specifically designed for and assigned to a certain action. The *Oxford Advanced Learner's Dictionary* defines a gesture as "a movement that you make with your hands, your head or your face to show a particular meaning" [10]. But what if there is no particular meaning to such a movement that you can show? What if the movement just exists, but does not have a defined function? Can we even call it a gesture or is just an undefined utterance of the body? Can we give it a function and meaning? To investigate, this paper makes a first attempt at exploring the following research questions:

- **RQ1**: What are the most common Null Gestures?
- **RQ2**: Can these undirected movements be transformed into actual gestures by giving them meaning and purpose with the help of the computer? How do they relate to the principles followed by other gesture-based approaches?
- **RQ3**: What could be their potential role in HCI?
- **RQ4**: What are the chances, limitations, and challenges?

To address these questions, this paper catalogues the most common Null Gestures (Study One) and attempts to capture these using the MYO armband [22]. A second study (Study Two) attempts to apply meaning to the most common Null Gestures using four applications, thereby elevating them from the status of being bare movements to that of potential gestures. A results section provides a quantitative and qualitative analysis, reporting on the gestures' performance and user acceptance. The paper concludes with a discussion of the concept and future work.

Contribution

This paper introduces the concept of the Null Gesture: Idle movements, that do not appear to have an intentional function in the real world, are being assigned a function in the human-computer dialogue. Contrary to established approaches [3, 12, 23], our work does not transfer meaning from the real world into HCI [19], but it creates meaning of something meaningless with the help of the computer. We evaluate this interaction concept for discrete, continuous and positional input and find that it may be used to support mouse or touch input by mapping frequently used functions to the Null Gestures. Qualitative feedback indicates high user acceptance and suggests that users see the newly discovered interaction potential as an enrichment to their HCI arsenal. By transforming inaction into interaction, Null Gestures present an unusual approach to HCI and open a largely unexplored design space, which we hope may help to smoothen the dialogue between human and computer.

Study One: Types of Null Gestures

In order to learn what types of Null Gestures people may perform, we conducted a series of informal interviews. Fifteen people (5 F, mean age: 33.3, SD: 9.2) were asked whether they had ever noticed that they take up certain stances or perform any actions when concentrating, thinking, or waiting, without a means of distraction to hand. We collected their responses as follows: By observing their actions while thinking of an answer (unconscious gestures) and by noting their actual responses (conscious gestures). The results can be found in Table 1. We limited our study to the four most frequently observed poses and movements of the upper body to define four Null Gestures:

- **NG1**: Resting one's head on one's palm and briefly tapping one's cheek with the index or middle finger (Fig. 2)

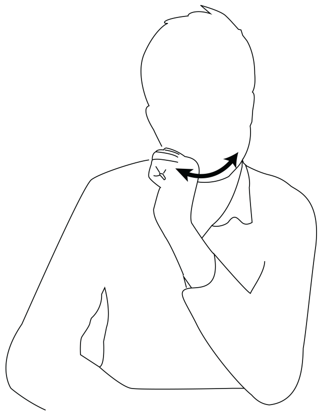

Figure 4: NG3: The user forms a fist and rubs the thumb along their chin forwards and backwards.

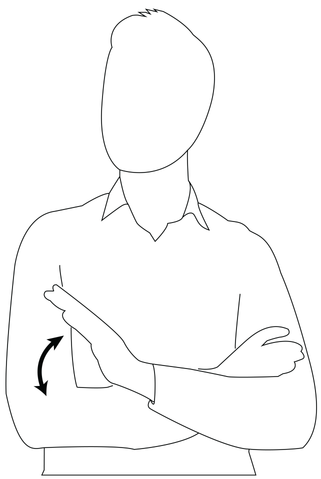

Figure 5: NG4: The user has their arms crossed and taps their hand once or twice.

- **NG2**: Using the same position as NG1, but leaving middle or index finger extended in a mid-tap position (Fig. 3)
- **NG3**: Rubbing one's chin from left to right with the back of the thumb (Fig. 4)
- **NG4**: Tapping one's hand once (single tap) or twice (double tap) on one's arm while the arms are crossed (Fig.5)

Gesture Detection

We captured the gestures using a MYO armband [22] and its JavaScript SDK. The MYO was employed for its mobility, ease of use, and rich sensor facilities [15, 25]. Two positions were defined from which common Null Gestures emerge:

***Position A*:** When users rest their head on their hand;
***Position B*:** When users have their arms crossed.

We extracted the X, Y, and Z orientation of the MYO in these poses and defined a tolerance of 15 degrees for each axis' rotation value. The position of the MYO is measured at 50Hz. If at least two values of its rotation vector match either range, the pose is detected.

NG1 (finger tap on cheek)
The data of the MYO's eight EMG sensors is sampled at 200Hz and stored in a buffer. Observations of the signals of two users (1F, mean age: 35, SD: 0) showed that a particular sensor had a strong signal for index and middle finger movement. We refer to this sensor as the "Cardinal Wave". If its buffer amplitude is above or below a specific threshold, recording starts or stops. All sensors' amplitudes are then evaluated while their relation to and correlation with each other is calculated using the Spearman Correlation Coefficient. Depending on the result, a tap with the index finger or middle finger is detected, if the MYO is in position *A*.

NG2 (extended finger tap gesture)
This uses the same approach as NG1 with the exception that if the Cardinal Wave's buffer amplitude does not fall for 1.2 seconds, it is continuously evaluated and, if conditions are met, an "extended" gesture is detected (Fig. 3).

NG3 (chin rub)
If the MYO is in position *A* and the user makes a fist for two seconds, the movement of the MYO will be monitored until the fist is released. By performing a "stroking" gesture with the back of the thumb along the chin within a range of 10° and back, a chin rub is detected (Fig.4). If the fist is opened within this time frame, the gesture is cancelled (Fig. 4).

NG4 (hand tap on arm)
If the MYO is in position *B*, the EMG data is monitored using the same approach as NG1, but with a different set of rules: If the extracted Cardinal Wave has a distinctive peak, amplitude and maximum length, a single tap is detected. If the signal has two peaks within a certain minimum and maximum distance that are above a certain threshold, a double tap is detected (Fig. 5).

A detected gesture is indicated on the screen to reassure the user. A pilot study with five male users (mean age 28.6, SD: 3.8) was conducted to test and adjust the classifier, which was the basis of our second user study. It should be noted that the aim and contribution of our work is not the detection of the subtle hand gestures. This has been done by previous work to a much higher standard [1]. Rather, this work's contribution is the definition of the concept of the Null Gesture and the exploration of its use in HCI. Our basic gesture detector only serves as a means to an end to capture these in a limited scope.

Slideshow technical information

Dimension: 1024 x 768 px

Screen: 27”, 1920 x 1200 px

Prev./Next: 43 x 28 px

Save button: 100 x 40 px

Slider size: 300 x 15 px

Rating widget: 200 x 46 px

Music player technical information

As users were not familiar with the music, the current track and position in the playlist were shown on a 27” screen in either mode, running in a Web browser on Mac OSX.

All tracks were embedded into this website, with input events sent via a specific Web Socket connection (phone, Normal mode) or directly via the MYO JavaScript library (NG mode).

Study Two: Application

To examine the Null Gestures’ potential use in HCI, we conducted a second study with 12 users (1F, mean age: 25.6, SD: 4.7) in four applications and one accuracy test, taking about one hour per user. We investigated the gestures’ use for discrete, continuous, and positional input, as a means to support mouse input or replace simple touch input.

To begin, users could explore the gestures in order to determine whether the MYO was placed correctly on their arm. While detection was reasonably accurate for the majority of participants by adjusting the armband’s position, detection thresholds had to be adjusted for two participants – a known challenge of EMG input [29, 1]. After this exploration and adjustment, users were asked to perform each gesture ten times in an accuracy test. Following this, they performed a round of actions with instruction from a researcher in four applications: Controlling a slideshow, manipulating the contrast of images, rating media items, and selecting tracks in a playlist. Each round had to be performed in two modes: Once using a Null Gesture in combination with the mouse or touch input (NG mode), and once using only mouse or touch input (Normal mode), depending on the application. After each application, users provided feedback on a five-point Likert scale regarding different usability aspects (Tab. 2). After all applications had been explored, users gave feedback regarding the concept of Null Gestures on a five-point Likert scale (Fig. 6, Fig. 7).

NG1: Slideshow control (discrete input)
Users controlled a slideshow, simulating the review of a set of photographs and “saving” them for further use. In Normal mode, users were instructed by a researcher to go to the next image five times by clicking the “Next” button and mark each image by clicking a “Save” button. After this, the same had to be done backwards using the “Previous” button. “Previous” and “Next” buttons were below the slideshow on the left and right, the “Save” button in the middle.

In NG mode, the function of the “Next” button was mapped to a tap with the index finger, the function of the “Previous” button to a tap with the middle finger (NG1 Fig. 2), and the “Save” button was operated with the mouse. Instructions were the same as in Normal mode.

NG2: Contrast control (continuous input)
Users controlled a slideshow with a contrast slider for each image, simulating the process of reviewing and enhancing photographs. In Normal mode, users were instructed by a researcher to go to the next image five times by clicking the “Next” button and changing the contrast of each image using a slider from 100 to 200. After this, the same had to be done backwards using the “Previous” button and changing the contrast to 100. “Previous” and “Next” buttons were situated below the slideshow on the left and right. The contrast slider was positioned in the middle.

In NG mode, the contrast control was mapped to the NG2 gestures (Fig. 3). Stretching out the index finger continuously increased the contrast, stretching out the middle finger reduced the contrast, moving the slider accordingly. “Previous” and “Next” buttons were controlled with the mouse and instructions were the same as in Normal mode.

NG3: Rating control (positional input)
Users controlled a slideshow together with a three-star rating widget, simulating the review and rating of media. In Normal mode, users were instructed to go to the next image five times by clicking the “Next” button and rate each image with a predefined number of stars using the mouse. After this, the same had to be done backwards using the “Previous” button. The “Previous” button was situated below the

NG	S1	S2	S3	S4	S5
1	4	4	4	4	5
2	4	4	4	4	4
3	4	4	3.5	4	4
4	4	4.5	4	4	4.5

Table 2: Median answers to five usability statements (S1–S5) concerning the four Null Gestures (NG) on a five-point Likert scale. The statements were answered after each application:

S1: The gesture was intuitive.

S2: The gesture felt natural.

S3: The gesture was easy to execute.

S4: The gesture was engaging.

S5: I would use it if it existed.

Please note: To save space, the results are presented in a table. To see the boxplots for each Null Gesture, please refer to the additional material uploaded with this paper.

slideshow on the left, the "Next" button on the right, and the rating widget in the middle.

In NG mode, "Previous" and "Next" buttons were operated using the mouse, and the rating was mapped to the gesture NG3: Depending on the position of the hand during the chin rub (Fig. 4), the rating widget was set to between zero and three stars. The rating was confirmed by releasing the fist, used as a delimiter (see section "Gesture Detection").

NG4: Music player (discrete input)
Users controlled the track selection in a music player, simulating skipping through a playlist. Users were asked to sit on a chair and cross their arms, taking up a "waiting" position, derived from our initial study (Tab.1). Instructed by a researcher, users were asked to interact with a smartphone lying on a table in front of them. Users were asked to tap the "Next" and "Previous" buttons ten times (five times each), both situated at the bottom of the phone screen. Users could either pick up the phone or operate it lying on the table. After each action they returned to their waiting pose for five seconds before performing the next action.

In NG mode, track selection was mapped to the NG4 gesture: With arms crossed, a tap with the left hand on the right arm selected the next track, a double tap the previous track. Instructions were the same as in Normal mode.

All applications
For technical details, please see the box "Slideshow technical information" in the margin on the previous page. Recording started by clicking a "Start" button in the centre of the screen using the mouse and ended by clicking the button again after all actions had been performed. During this, all input (mouse movement, clicks, gestures) was recorded. Errors could not be made, but all actions had to be performed. We did not record task completion times, as this work presents an initial investigation of Null Gestures with untrained users. The study was counterbalanced by mode of operation (Normal mode, NG mode) and application.

Results

Mean gesture classification accuracy is as described in Table 3. Accuracy is reasonably high due to the per-user calibration and limited gesture set.

NG	IFS	MFS	IFH	MFH	ATS	ATD	RUB
IFS	**90**	5	4.2	0.8	0	0	0
MFS	1.7	**96.6**	0	1.7	0	0	0
IFH	0.8	1.7	**95**	2.5	0	0	0
MFH	0	9.2	1.7	**89.1**	0	0	0
ATS	0	0.8	0	0	**96.7**	2.5	0
ATD	0	0	0	0	27.5	**72.5**	0
RUB	0	6.7	0.8	4.2	0	0	**88.3**

Table 3: The mean detection accuracy of the four Null Gestures over 10 repetitions per gesture in percent. **NG1:** Index finger single tap (IFS), middle finger single tap (MFS). **NG2:** Index finger hold-out (IFH), middle finger hold-out (MFH). **NG3:** Arm tap single (ATS), arm tap double (ATD). **NG4:** Chin rub (RUB).

To gauge the difference in amount of interactions between Normal mode and NG mode, we evaluated each application using a Wilcoxon test. We chose this test over the ANOVA due to the small sample size – thus focussing on the median rather than the mean – and the fact that our independent variable only had two levels (Normal mode, NG Mode).

NG1: Slideshow control
A Wilcoxon test indicated that supporting mouse input with Null Gestures (median: 123.5) allowed users to complete tasks with less interactions and mouse movement than mouse-only input (median: 1235), $Z = 3.06$, $p = .002$. The

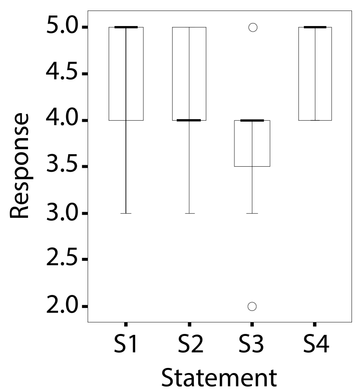

Figure 6: Feedback of the 12 users of Study Two regarding the Null Gesture concept using statement one to four (S1–S4) on a five-point Likert scale. The statements were answered after all applications had been explored

S1: I like that a previously meaningless gesture now has a function.

S2: I like maintaining the same pose and executing actions from it.

S3: Null Gestures have helped me realise potential of my body I had not considered using.

S4: Null Gestures have enriched my interaction "arsenal" for HCI.

qualitative feedback showed high user acceptance (Tab. 2). When users were asked what else they would use NG1 for, the three most-frequent responses were "flipping pages and scrolling" (6), "shortcuts" (2), and "tab switching" (2).

NG2: Contrast control
A Wilcoxon test indicated that supporting mouse input with Null Gestures (median: 335) allowed users to complete tasks with less interactions and mouse movement than mouse-only input (median: 1816), $Z = 3.06$, $p = .002$. The qualitative feedback indicated high user acceptance (Tab. 2). When users were asked what else they would use NG2 for, the three most-frequent responses were "media playback control" (4), "scrolling" (4), and "controlling sliders in applications" (3).

NG3: Rating control
A Wilcoxon test indicated that supporting mouse input with Null Gestures (median: 283) allowed users to complete tasks with less interactions and mouse movement than mouse-only input (median: 1377.5), $Z = 3.06$, $p = .002$. The qualitative feedback indicated high user acceptance, but people were undecided regarding the ease of control (Tab. 2). When users were asked what else they would use NG3 for, the three most-frequent responses were "scrolling" (3), "volume control" (3), and "slider control" (2).

NG4: Music player
A Wilcoxon test was not significant. The median amount of interactions needed was similar for Normal mode (median: 10) and NG mode (median: 11), explainable by the classifier's inaccuracy. Qualitative feedback was positive (Tab. 2). When users were asked what else they would use NG4 for, the three most-frequent responses were "control of the computer or TV while in a relaxed position" (3), "skipping through videos" (3), and "presentations" (2).

General qualitative feedback
Figure 6 and Figure 7 show the general qualitative feedback regarding the Null Gesture concept. Opinions were largely positive and encourage further exploration.

Discussion

This section will discuss the four initial research questions, aiming to define use, classification, and challenges.

RQ1: What are the most common Null Gestures?
We introduced the concept of the Null Gestures, which we define as meaningless and undirected movements that emerge from a certain physical pose or mental state and whose assignment in culture and HCI is "Null" (see margin box after the next page for a definition). Based on Study One, the most common Null Gestures appear to be: Resting one's head or cheek on one's head, rubbing one's chin, tapping one's foot, tapping one's finger on one's face, arm or surface, and crossing one's arms (Tab.1). However, it has to be considered that this list may not be exhaustive due to the limited sample size, and others may be possible. In this first exploration, we focussed on the most common Null Gestures performed with the upper body.

RQ2: Can these undirected movements be transformed into actual gestures by giving them meaning and purpose with the help of the computer? How do they relate to the principles followed by other gesture-based approaches?
To investigate the potential of giving the Null Gestures meaning and purpose with the help of the computer, four applications have explored their use for discrete, continuous, and positional input, as a means to support mouse input or to replace touch input. **By giving these undirected movements meaning and function, the computer has allowed us to transform them into actual gestures** according to the *Oxford Advanced Learner's Dictionary* defi-

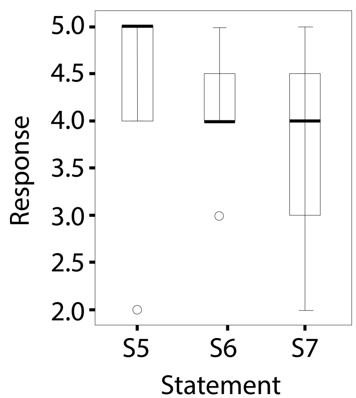

Figure 7: Feedback of the 12 users of Study Two regarding the Null Gesture concept using statement five to seven (S5–S7) on a five-point Likert scale. The statements were answered after all applications had been explored.

S5: I like using Null Gestures to support mouse input.

S6: I like using Null Gestures to replace touch input.

S7: I felt closer or "more connected" to the computer.

nition [10]. The concept and assigned meaning were positively received by users (Fig. 6, Fig. 7, Tab. 2).

But how do Null Gestures relate to the principles that are followed by other established gesture-based approaches [3, 12, 23]? Although a discussion of this aspect can by no means be exhaustive in this exploratory paper, we would like to at least make a first start, as it may help to further understand the characteristics of Null Gestures in HCI. By using "computation as a medium" [11, p. 162], actions have been turned into meaning and thus one may argue that the thereby defined ~~Null~~ Gestures may correspond to the principles of embodied interaction [11, chap. 6]: In the environment of the human-computer dialogue, they have been given meaning and purpose by being assigned a function in a certain application and thereby have become non-null and are no longer meaningless, but meaningful. Yet, by doing so, they may only fit the definition of a gesture [10] in the context of HCI. Therefore, it may be questionable whether they fit into Jacob et al.'s [19] concept of RBI: Although they are in the real world and are just like the real world, their assignment and function only exist within the human-computer dialogue, meaning that they may have more "power" than "reality" [19, p. 2468]. While knowledge of the involved motor abilities exists and is transferred to HCI, knowledge of purpose and meaning is not, as none has been assigned in the real world.

RQ3: What could be their potential role in HCI?
The answer to *RQ2* has already mentioned the Null Gestures' use for different types of input (discrete, continuous, positional, supportive or replacing). In addition to this, the results have shown that when using the Null Gestures, the number of interactions for certain repetitive tasks was lowered. This was expected, as the Null Gestures had been given specific functions, similar to hotkeys, and thus the need for mouse movement was reduced. Yet, despite the small sample size, the results may hint towards the potential role of Null Gestures in HCI: **That of shortcuts for frequently used functionality**. This attribution is further supported by users' subjective feedback regarding their potential use in other applications (see section "Results"). However, to further validate this finding, chronometric measurements need to be taken in a future study that goes beyond the exploration of the concept.

RQ4: What are the opportunities and challenges?
Null Gestures may hold various opportunities: If we assume that Null Gestures are the result of aiming to improve concentration [28] or utterances of idleness, their use in situations of focus or boredom may be an adequate placement. By assigning meaning to these in the human-computer dialogue, users can communicate with the machine without having to leave their ponderous state and change their position to a dedicated communication posture, such as putting their fingers on the keyboard. In this regard, Null Gestures may not possess an acquisition time, as they are performed and emergent from the user's current position and state. They thus may serve in sustaining the user's concentration and focus, and tighten the bond between human and computer by enabling us to communicate in a natural, known, but yet undiscovered manner, as indicated by the user feedback (Fig. 6, Fig. 7). Following this, Null Gestures may not only give us the opportunity to extend our HCI vocabulary, but may also help us realise bodily potential we may not have considered using before (Fig. 6). But the concept also faces various challenges: Users may inadvertently perform a gesture while being idle, suggesting the need for a more robust classifier, as presented by Amma et al. [1], or better gesture delimiters. Further, making increased use of previously infrequently used muscle groups may put unusual strain onto users. Most important, though, may be the

Null Gesture definition

- The "gesture" naturally emerges from a pose or state of concentration or boredom in the real world.
- The "gesture" does not have a specific function or purpose in the real world, its assignment is "Null".
- The naturally emerging and functionless "gesture" is given function and meaning with the help of the computer. As a result, the creation and assignment of meaning does not lie with the human entity, but with the machine, and depends on the context. The Null Gesture is elevated from being a mere bodily utterance to the state of an actual gesture [10].
- The user thereby discovers previously unrecognised bodily potential that enriches their dialogue with the machine. At the same time, utilisation of said potential may be confined to this dialogue.

question regarding the possible dangers but also chances of suddenly giving a meaning to something that has been meaningless for so long. If Null Gestures were used in HCI, would it affect human motor behaviour when idle or concentrated? Further, the concept questions the ownership of the creation of meaning in modern life: Whereas historically this lies with humans and is based on the cultures they create and live in, the Null Gesture concept suggests that this role, at least to an extent, may also be taken up by the computer. This presents a fundamental challenge to the way we perceive machines. In a time where more and more aspects of our work and even social life are administered by computers, is it not a logical consequence that the computer is finally transformed from a mindless tool to a contributor to culture when it creates meaning and helps us discover our potential? In this regard, we may look at Williams's [34] two-part model of culture from a very different point of view: Here, the human-created elements of culture are the "known meanings and directions, which its members are trained to". However, the second part, the "new observations and meanings, which are offered and tested" may be those meanings the computer creates and offers for inclusion into a society whose life so closely revolves around technology. This prompts an extension to William's well-known statement: "Culture is [an] ordinary [function]." With increasing powers being attributed to AI, we believe this to be an important point of discussion which we hope the diverse CHI community can offer insight into.

Limitations

We only explored the concept of the Null Gesture using four gestures with a limited scope and a limited sample size. If more gestures were evaluated, a more robust gesture detector or even a different method, such as motion tracking [18], may be required. In addition, the chin rub gesture (NG4) had to be adapted slightly from its original typical movement path to better work with the MYO. Further, to perform the study, we had to take up the initial role of the creator of meaning by assigning functions to the gestures in the examined application – a step that should be taken by the computer based on the context, if we stay true to the Null Gestures' definition. In addition, users were asked to take up a pose of concentration or idleness deducted from Study One. By doing so, one could argue that they had to take up an "active" communication pose, which is an aspect of gesture-based HCI that Null Gestures should help to reduce, rather than instigate. Ideally, Null Gestures can be performed from any pose. In this regard, this paper has only presented a first exploration of the potential of the concept and its use in HCI. Future work should evaluate longitudinal, real-life studies for a more realistic investigation.

Context and Previous Work

In the context of gesture-based interaction, our work extends that of others who have utilised EMG signals in HCI, be it for music control [30], subtle mobile input [8], to augment touch [4], for the creation of new pointing methods [15], or for giving another dimension of complexity to gestures [7]. Our work further capitalises on insights of previous work that has not only explored input with the body, but also on it: Subtle interactions have been explored by embedding sensors into clothes [27], by using interface "stickers" on the skin [33], and by using differences in electrical signatures of various body parts, measured with a ring [24].

Regarding the inclusion of idle actions into HCI, researchers have begun to investigate the concept of supporting a "cognitive and emotional state of a user" [20, p. 1151] through the provision of tangible Sifteo blocks, held in the hand or positioned on the table. These allow and stimulate "playful interactions" while focussing on another task [20]. Others have aimed to disguise targeted and defined gestures as “idle fidgeting” for secretive, purposeful input [2]. For example, their goal was to disguise the purposeful and targeted touching of a phone as “idle fidgeting” by following the principles of magic and illusion to increase privacy.

In contrast, our work presents a first attempt to exploit the potential of this “idle fidgeting” as such by directly capturing it where it occurs: On the body, without a tangible device. Using four applications we have given meaning to the meaningless, a direction to what was previously undirected and thereby transformed these movements into gestures [10]. We thereby illustrated how the computer could be used to help users discover unused motor abilities by giving meaning and function to something that had none.

In addition to this concept, our work may also offer a first answer to the question of Amma et al. [1] concerning the role that subtle finger movements may play in HCI, as these are part of two of the examined Null Gestures (NG1 and NG2, Fig. 2 and Fig. 3). Although the use of finger movements has already been explored for music control [29], our work extends the application domain by examining them as a means to support mouse input in the form of hotkeys or shortcuts. In this regard, it may also offer a first answer to Karlesky and Isbister’s question “How can we facilitate fidgeting?” [20]: By harnessing such movements where they occur, without acquiring specific devices, and assigning them meaning in the human-computer dialogue.

Changing perspectives

Building on previous work regarding subtle and unsubtle input via EMG and Inertial Measurement Units (IMUs), our work may offer a change in perspective: On the one hand, we harness an existing but undirected and undefined movement and give it direction and meaning with the help of the computer. This way, it is not the human who defines meaning and function, but the computer who transforms these Null Gestures into actual gestures and thus helps us perceive these as such (Fig. 6). On the other hand, the concept of the Null Gesture as the transformation of a natural, situationally emerging utterance of the body into a meaningful expression reduces the need for us to adapt to the computer by learning new movements and engaging with it in a focussed “lean-forward” pose. Rather, we may perform these gestures in a position where we do not lean particularly forwards or backwards, but lean on ourselves. As the gestures may emerge naturally from such a position (Tab. 1), the computer just interprets them, reducing the need for postural change and possible acquisition time if we already are in such a position. Whereas previous work has used either existing or purposefully designed meaning for the human-computer dialogue [19], our work *creates* meaning of something previously meaningless, unveiling a new design space for HCI, ready to be explored and colonised. It is this introduction of the paradigm of transforming inaction into interaction that we would like the reader to perceive as our work’s main contribution and stimulus for discussion.

Future work

Future work will explore additional gesture delimiters, extend the exploration to other applications and Null Gestures as defined in Table 1 together with their social acceptability, and consider using other technologies to capture these, such as motion tracking [18]. Long-term we will explore whether Null Gestures can help change our view of the computer from a device we use to solve problems to that of a device we use to discover our abilities.

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References

[1] Christoph Amma, Thomas Krings, Jonas Böer, and Tanja Schultz. 2015. Advancing Muscle-Computer Interfaces with High-Density Electromyography. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems (CHI '15)*. ACM, New York, NY, USA, 929–938. DOI: http://dx.doi.org/10.1145/2702123.2702501

[2] Fraser Anderson, Tovi Grossman, Daniel Wigdor, and George Fitzmaurice. 2015. Supporting Subtlety with Deceptive Devices and Illusory Interactions. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems (CHI '15)*. ACM, New York, NY, USA, 1489–1498. DOI: http://dx.doi.org/10.1145/2702123.2702336

[3] Thomas Baudel and Michel Beaudouin-Lafon. 1993. Charade: Remote Control of Objects Using Free-hand Gestures. *Commun. ACM* 36, 7 (July 1993), 28–35. DOI: http://dx.doi.org/10.1145/159544.159562

[4] Hrvoje Benko, T. Scott Saponas, Dan Morris, and Desney Tan. 2009. Enhancing Input on and Above the Interactive Surface with Muscle Sensing. In *Proceedings of the ACM International Conference on Interactive Tabletops and Surfaces (ITS '09)*. ACM, New York, NY, USA, 93–100. DOI: http://dx.doi.org/10.1145/1731903.1731924

[5] William Buxton, Ralph Hill, and Peter Rowley. 1985. Issues and Techniques in Touch-sensitive Tablet Input. In *Proceedings of the 12th Annual Conference on Computer Graphics and Interactive Techniques (SIGGRAPH '85)*. ACM, New York, NY, USA, 215–224. DOI: http://dx.doi.org/10.1145/325334.325239

[6] Gyorgy Buzsáki, Adrien Peyrache, and John Kubie. 2015. Emergence of Cognition from Action. *Cold Spring Harbor Symposia on Quantitative Biology* (2015). DOI: http://dx.doi.org/10.1101/sqb.2014.79.024679

[7] Baptiste Caramiaux, Alessandro Altavilla, Scott G. Pobiner, and Atau Tanaka. 2015. Form Follows Sound: Designing Interactions from Sonic Memories. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems (CHI '15)*. ACM, New York, NY, USA, 3943–3952. DOI: http://dx.doi.org/10.1145/2702123.2702515

[8] Enrico Costanza, Samuel A. Inverso, and Rebecca Allen. 2005. Toward Subtle Intimate Interfaces for Mobile Devices Using an EMG Controller. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '05)*. ACM, New York, NY, USA, 481–489. DOI: http://dx.doi.org/10.1145/1054972.1055039

[9] Juan D. Delius. 1967. Displacement Activities and Arousal. *Nature* 214, 5094 (June 1967), 1259–1260. DOI: http://dx.doi.org/10.1038/2141259a0

[10] Oxford Advanced Learner's Dictionary. 2016. Gesture. (2016). http://www.oxforddictionaries.com/definition/learner/gesture

[11] Paul Dourish. 2001. *Where the action is: the foundations of embodied interaction*. MIT press, Cambridge, MA.

[12] Kenneth P. Fishkin, Anuj Gujar, Beverly L. Harrison, Thomas P. Moran, and Roy Want. 2000. Embodied user interfaces for really direct manipulation. *Commun. ACM* 43, 9 (Sept. 2000), 74–80. DOI: http://dx.doi.org/10.1145/348941.348998

[13] David Fraser. 2008. *Understanding Animal Welfare: The Science in its Cultural Context*. Wiley-Blackwell.

[14] Anthony Ha. 2015. Spotify Unveils New Features For Runners, Including Songs That Change Based On Your Tempo. (March 2015). http://social.techcrunch.com/2015/05/20/spotify-for-runners/

[15] Faizan Haque, Mathieu Nancel, and Daniel Vogel. 2015. Myopoint: Pointing and Clicking Using Forearm Mounted Electromyography and Inertial Motion Sensors. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems (CHI '15)*. ACM, New York, NY, USA, 3653–3656. DOI: http://dx.doi.org/10.1145/2702123.2702133

[16] Chris Harrison, Desney Tan, and Dan Morris. 2010. Skinput: Appropriating the Body As an Input Surface. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '10)*. ACM, New York, NY, USA, 453–462. DOI: http://dx.doi.org/10.1145/1753326.1753394

[17] Debby Hindus, Barry Arons, Lisa Stifelman, Bill Gaver, Elizabeth Mynatt, and Maribeth Back. 1995. Designing Auditory Interactions for PDAs. In *Proceedings of the 8th Annual ACM Symposium on User Interface and Software Technology (UIST '95)*. ACM, New York, NY, USA, 143–146. DOI: http://dx.doi.org/10.1145/215585.215713

[18] Leap Motion Inc. 2016. Leap Motion | Mac & PC Motion Controller for Games, Design, Virtual Reality & More. (2016). https://www.leapmotion.com/

[19] Robert JK Jacob, Audrey Girouard, Leanne M Hirshfield, Michael S Horn, Orit Shaer, Erin Treacy Solovey, and Jamie Zigelbaum. 2007. Reality-based interaction: unifying the new generation of interaction styles. In *CHI'07 Extended Abstracts on Human Factors in Computing Systems*. ACM, 2465–2470.

[20] Michael Karlesky and Katherine Isbister. 2013. Fidget Widgets: Secondary Playful Interactions in Support of Primary Serious Tasks. In *CHI '13 Extended Abstracts on Human Factors in Computing Systems (CHI EA '13)*. ACM, New York, NY, USA, 1149–1154. DOI: http://dx.doi.org/10.1145/2468356.2468561

[21] Myron W. Krueger, Thomas Gionfriddo, and Katrin Hinrichsen. 1985. Videoplace – an Artificial Reality. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '85)*. ACM, New York, NY, USA, 35–40. DOI: http://dx.doi.org/10.1145/317456.317463

[22] Thalmic Labs. 2015. Myo Gesture Control Armband. (2015). https://www.myo.com/

[23] Lian Loke and Toni Robertson. 2013. Moving and Making Strange: An Embodied Approach to Movement-based Interaction Design. *ACM Transactions on Computer–Human Interaction* 20, 1 (April 2013), 7:1–7:25. DOI: http://dx.doi.org/10.1145/2442106.2442113

[24] Denys J. C. Matthies, Simon T. Perrault, Bodo Urban, and Shengdong Zhao. 2015. Botential: Localizing On-Body Gestures by Measuring Electrical Signatures on the Human Skin. In *Proceedings of the 17th International Conference on Human-Computer Interaction with Mobile Devices and Services (MobileHCI '15)*. ACM, New York, NY, USA, 207–216. DOI: http://dx.doi.org/10.1145/2785830.2785859

[25] Kristian Nymoen, Mari Romarheim Haugen, and Alexander Refsum Jensenius. 2015. MuMYO–Evaluating and Exploring the MYO Armband for Musical Interaction. (2015).

[26] Rosalind W. Picard. 2015. Recognizing Stress, Engagement, and Positive Emotion. In *Proceedings of the 20th International Conference on Intelligent User Interfaces (IUI '15)*. ACM, New York, NY, USA, 3–4. DOI: http://dx.doi.org/10.1145/2678025.2700999

[27] J. Rekimoto. 2001. GestureWrist and GesturePad: unobtrusive wearable interaction devices. In *Wearable Computers, 2001. Proceedings. Fifth International Symposium on*. 21–27. DOI: http://dx.doi.org/10.1109/ISWC.2001.962092

[28] Roland Rotz and Sarah D Wright. 2005. *Fidget to Focus: Outwit Your Boredom–Sensory Strategies for Living with ADD*. iUniverse.

[29] T. Scott Saponas, Desney S. Tan, Dan Morris, Ravin Balakrishnan, Jim Turner, and James A. Landay. 2009. Enabling Always-available Input with Muscle-computer Interfaces. In *Proceedings of the 22nd Annual ACM Symposium on User Interface Software and Technology (UIST '09)*. ACM, New York, NY, USA, 167–176. DOI:http://dx.doi.org/10.1145/1622176.1622208

[30] Atau Tanaka. 1993. Musical technical issues in using interactive instrument technology with application to the BioMuse. In *Proceedings of the International Computer Music Conference*. International Computer Music Conference, 124–124.

[31] Atau Tanaka, Alessandro Altavilla, and Neal Spowage. 2012. Gestural Musical Affordances. *Proceedings of the 9th Sound and Music Computing Conference* (2012), 318–325. http://smcnetwork.org/resources/smc2012

[32] Chi Vi and Sriram Subramanian. 2012. Detecting Error-related Negativity for Interaction Design. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '12)*. ACM, New York, NY, USA, 493–502. DOI:http://dx.doi.org/10.1145/2207676.2207744

[33] Martin Weigel, Tong Lu, Gilles Bailly, Antti Oulasvirta, Carmel Majidi, and Jürgen Steimle. 2015. iSkin: Flexible, Stretchable and Visually Customizable On-Body Touch Sensors for Mobile Computing. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems (CHI '15)*. ACM, New York, NY, USA, 2991–3000. DOI:http://dx.doi.org/10.1145/2702123.2702391

[34] Raymond Williams. 2011. Culture is ordinary (1958). In *Cultural theory: An anthology*, Imre Szeman and Timothy Kaposy (Eds.). Wiley-Blackwell, Chichester, Chapter 5, 53–59.