Takt: a wearable timepiece that enables sensory perception of time

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Abstract

We live in a time-dependent society where everyone relies on time. Time controls our lives, to the extent where every day is planned after activities at specific points in time. Research shows that people with ADHD have difficulties adjusting to the normative structure of time. Through an iterative participatory design process with students diagnosed with ADHD, different conceptions and representations of time were explored. Based on the findings that visual resources are used to understand the duration of time and the lack of an internal clock to help tell the passage of time a final design were created, called Takt. Takt rely on the senses of touch and vision to enable users to tell the passage of time using their senses rather than relying on the cognition required to read the information on a clock, to provide users with a sense of control over time.

Author Keywords

Time perception; ADHD; Wearable technology; Assistive technology; Participatory design; Haptic

ACM Classification Keywords

H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

Introduction

In an attempt to make time less abstract, people have organised the concept of time in terms that can be understood by most. We have even created a technology to support our time processing ability, in the form of the traditional clock. Our society is dependent and structured around the normative conception of time that is reinforced by the design of the clock. But what if you make sense of time differently than the norm?

The understanding of time is learnt and developed as an ongoing process until we reach a certain age [6], and when people reach adulthood they usually have a built in clock to help them passively approximate the passage of time [1]. Through continuous learning and memorising, people develop the ability to match the passage of time with the information on the clock [6]. However, even though most can learn to tell the time with the use of a traditional clock, not all can make use of the information.

People diagnosed with ADHD who have a different way of making sense of time may be unable to efficiently allocate time within the normative structure. This deviation makes it more difficult adjusting to a time-dependent society, resulting in a higher risk of becoming more dependent on others as well as making everyday life situations and contexts challenging [5]. School for example is supposed to provide equal opportunities to all students according to Lgr11 [8] (curriculum for the compulsory school, preschool and the recreation centre in Sweden) but is still structured around the normative structure of time, making it more challenging for a child with ADHD, emphasising the need for enabling individual independence in youths and tools to support time abilities.

Background

Research show that children with ADHD tend to have difficulties developing their time processing ability, which includes time perception, time management and time orientation, compared with children not diagnosed with ADHD [5] Sequencing and duration are the two components necessary for understanding of time and both require time sense (perception) and ability to allocate focus - both challenging aspects for people with ADHD [2].

Difficulties with time perception may have cascading effects on time orientation and time management, resulting in e.g. missed deadlines and appointments [10], that ultimately can lead to stress and anxiety among other symptoms [5]. Time perception deficit can also cause the assignment of a decreased value to delayed rewards as a consequence of overestimation of the duration of time intervals - all of which relates to other characteristics of ADHD such as impulsivity, concentration difficulties, frustration and dependency [9] Findings in literature also indicates that people with ADHD make use of visual-spatial processing as an additional cognitive resource to make sense of time [10].

Preliminary Research

Initial research into existing cognitive aids along with a visit at Stockholm Centre for Communicative & Cognitive Support (StoCKK) revealed that there are multiple time management tools that make use of the sequencing of activities and colour coded scheduling.
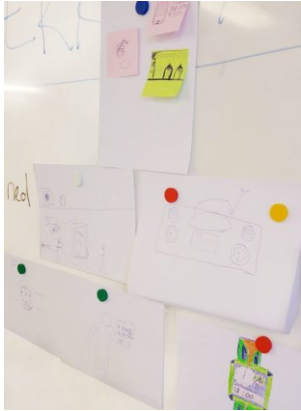
Figure 1: Participants solutions in the Future Workshop. Top: A fun-to-use Teleport. Middle: Route-to-bed routine and artefact. Lower: Wristband watch with multiple functionalities and time representations.
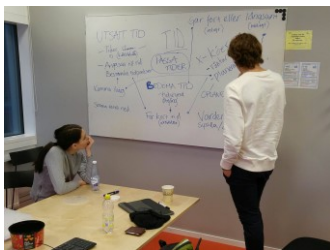

Figure 2: Affinity diagram, analysis of the result from the Future Workshop.

There is however a general lack of mobility and tools that transition between different situations.

To further understand the challenges related to time and how people with ADHD make sense of time, in-depth semi structured interviews were conducted that yielded information about how stress arise when activities take longer than expected and how changes in schedules creates stress**.**

Participatory Design
Working with a group of people marginalised by the norm a participatory design approach was adopted throughout the research project to distribute power to the user whose lives might be affected by the design [3].

A special education school for people with ADHD were involved in the research. A group of pupils between the ages 13-16 participated in different workshops throughout the design process. Findings in literature and preliminary research show that youths have the least experience of independently handling their diagnosis, whereas independency is a core value for teenagers [7].

Future Workshop
The first held workshop was a future workshop that focused on the challenges with time and retrieval of information as to how time is being made sense of by the participants. Going through three different stages known as the critique phase, fantasy phase, and implementation phase; participants accounted for current problems and expected features of a possible design solution [4]. Findings include:

The sequence of activities is more important than points in time
A common theme among these solution was an emphasis on activities rather than occurrences at given points in time. That is to say time being organised into activities in a certain order as a stretch of time, rather than its relation to specific hours and minutes.

The artefact needs to be available in multiple contexts
The participants expressed a need for extended support with a device that functions at more times and in several contexts, coherent with the findings from the preliminary research.

The representation of the traditional clock is not enough
Solutions contained multiple representations of time, indicating insufficiency with traditional time keeping and need for a more useful representation of time.

The artefact should be fun to use
The artefact should be customisable to make it a more diverse and fun experience to use.

It was evident that participants were familiar with existing assistive technologies for time management, such as timers and Time Timer, which to some extent might have influenced their perception of the task and thereby the outcome, but could also point to efficiency of colour coding and sequencing of activities in alignment with findings from our preliminary research.

Initial Design
Based on the research findings, a prototype (see figure 3) and design concept was created to help users conceptualise time by challenging how time is represented and can be perceived. The design features:

Figure 3: The prototype is a programmed Arduino Flora with a NeoPixel ring that counts down the time of an activity. A pixel lamp that goes out after a pre-set interval. The prototype also features a vibration motor and haptic engine that vibrates continuously - all enclosed in a 3D-printed case.

Figure 4: Examples of participants' paper and lo-fi prototypes from the circle session.

Haptic feedback
A constant, interval-set vibration that continuously indicates the passage of time to the user. In accordance with the findings of how people with ADHD make sense of time, the continuous vibration works as an external tool to support the person's inner clock.

Visualisation of time duration
The artefacts tells the duration of an activity in contrast to a traditional watch which tells the present time. The visualisation is based on the length of an activity (a morning routine, the length of a school lecture, the reading of homework), and displays the duration of the activity, how much time has passed and how much time is left until the activity ends.

Cognitive relief
To reduce the cognitive burden, the visualisation of time will only be visible when an activity is ongoing or when activated by a user. Information is thereby only shown when needed and accessed by an active user.

Flexible handling
The artefact should enable easy manipulation of setting the time of an activity. In case an activity takes longer than expected, ends sooner or is cancelled this will counter any additional stress and anxiety that arise with sudden changes or not being able to finish an activity in time.

Customisable features
Users are provided with increased control and flexibility through the ability to adjust the artefact to attend their personal needs. Main functions such as interval lengths of the vibration, colours for the visualisation and how it can be worn are all customisable.

Circle session

Three design activities were combined for the second encounter with the participants: Paper prototyping with sketching to investigate the artefact's role and how time should be represented. Lo-fi prototyping with clay to explore shape, form and wear. Evaluation of the prototype to elicit user requirements in a small focus group setting. In the first session, the participants' level of concentration seriously decreased towards the end. The participants cognitive challenges had to be further attended to, and based on these learnings the second encounter was made into what we refer to as a circle-session. Participants engaged in one design activity for a certain time, then the activities were circled as the researcher matched level of engagement with the length of the activity. Findings include:

Settings option that can regulate intervals, colours and vibrations
The wish for different vibration-intervals at different occasions and depending on personal needs confirmed previous findings. The artefact should allow changing main settings.

It should be operated and set up without an app
Not having to rely on an external app to change activity settings is important to make the artefact more useable and provide the user with a sense of control.

Colours should change depending on activity
The colours of the visualisation should be related to type of activity or time of day (morning, day or evening)

The artefact should synchronise with the calendar on your smartphone
If a user already have activities planned on their smartphone, they should not have to re-enter their schedule.

Activity-based visualised countdown
The artefact will light up completely and start counting down, no matter if the activity spans for a couple of minutes or several hours.

The power dynamic between researcher and participant and continuous presence of the research team during the workshops could well have influenced the outcome of the data. The benefits of being able to help the participants grasp the concept and ideas of the workshop however were recognised as outweighing given the limited number of visits at the school that were at disposal.

Final Design
The result of the conducted project is a product we have named Takt (see figure 5), the Swedish equivalent for the English word "pace", and reference to the English word "tactile" (sense of touch).

With the use of a continuous gentle vibration and visual feedback of the passage of time - Takt relieves the stressful cognitive load from the user. The visualisation can be personalised to suit the user's own preference in colour and brightness. Takt is designed to be used with interchangeable accessories making it wearable at any occasion, no matter the context. Attach it to a wristband, put it on a table or why not wear it as a necklace. Takt automatically adapts to the calendar on your current device, so you don't have to schedule

things more than once. If the duration or start of an activity does not match with your pre-set schedule or chosen time frame, Takt can also be adjusted manually by turning the upper part to set or extend an activity. By alluding to the senses of touch and vision, Takt is designed to help users feel time rather than tell time - resulting in a more accessible take on the passage of time.

Conclusion
For people with ADHD, the normative way of conceptualising time can result in emotional distress and difficulties to function independently in our time-depending society, and the traditional clock offers no support. Takt, the result of a participatory design process, uses haptic feedback to continuously remind its users of the passage of the time, a visualisation of duration that focuses on activities rather than points in time and customisability that enables users to interact with Takt their way.

Future research
Going forward, the next step in the design process would be to continue the iterative cycle and create a prototype that enables the evaluation of the final design. As other people or groups suffer from time deficits or challenges related to time similar to those of ADHD, it is relevant to further investigate if Takt could benefit other user groups.

Acknowledgements

Figure 5: Takt, the final design. Also features a bottom that attaches to magnetic surfaces and a top button used to interact with the device to show the exact time if needed.

References

1. Melissa J. Allman, Sundeep Teki, Tim D. Griffiths and Warren H. Meck. 2013. Properties of the internal clock: first- and second-order principles of subjective time. In *Annu. Rev. Psychol*. 2014;65, 743-71.

2. Russell A. Barkley. 1997. Attention-deficit/hyperactivity disorder, self-regulation, and time: toward a more comprehensive theory. In *Journal of Developmental and Behavioral Pediatrics*, 18:4, 271-279.

3. Erling Björgvinsson, Pelle Ehn and Per-Anders Hillgren. 2012. Agonistic participatory design: working with marginalised social movements. In *CoDesign: International Journal of CoCreation in Design and the Arts*, 8:23, 123-144.

4. Joan Greenbaum and Morten Kyng. 1991. *Design at Work – cooperative design of computer systems*. Lawrence Erlbaum Associates, Hillsdale, NJ, US.

5. Gunnel Janeslätt. 2009*. Time for time - assessment of time processing ability and daily time management in children with and without disabilities*. Ph.D. dissertation. Karolinska Institutet, Stockholm, SWE.

6. Jean Piaget. 2006. *The child's conception of time* (2nd·ed.). Routledge and Kegan Paul Ltd, London, UK.

7. The National Board of Health and Welfare (Socialstyrelsen). 2015. Användningen av centralstimulantia vid adhd –utvecklingen regionalt och i riket. Retrieved January 12, 2016 from http://www.socialstyrelsen.se/publikationer2015/2015-5-12.

8. The Swedish National Agency For Education (Skolverket). 2015. Curriculum for the compulsory school, preschool class and the recreation centre. 2011. Retrieved January 12, 2016 from http://www.skolverket.se/publikationer?id=2687.

9. Marc Wittmann and Martin P. Paulus. 2008. Decision making, impulsivity and time perception. In *Trends in Cognitive Science,* Jan 12(1), 7-12.

10. Vincent Quartier, Grégoire Zimmermann and Sadegh Nashat. 2010. Sense of Time in Children with Attention-Deficit/Hyperactivity Disorder (ADHD): A Comparative Study In *Swiss Journal of Psychology*, Vol 69:1,7-14.

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