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Capturing Thoughts, Capturing Minds?

- from Think Aloud to Participatory Analysis

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Abstract:
Think Aloud is cost effective, promises access to the user's mind and is the applied usability technique. But "keep talking" is difficult, besides, the multimodal interface is visual not verbal. Eye-tracking seems to get around the verbalisation problem. It captures the visual focus of attention. However, it is expensive, obtrusive and produces huge amount of data. Besides, eye-tracking do not give access to user's mind.
Capturing interface/cursor tracking may be cost effective. It is easy to install, data collection is automatic and unobtrusive and replaying the captured recording to the user and probing about her actions and thoughts open for participatory analysis.

Keywords
usability test, cost effective, unobtrusive, TA, eye and cursor tracking, user experience, participatory analysis

INTRODUCTION
Among usability techniques, Think Aloud (TA) is one of the most popular, used equally by industry and academia (Boren and Ramey,2000). It should be stressed here that there is an understanding in usability testing that one does not rely on data from one technique only, e.g. TA but combine with data from other techniques, and one of most frequently applied following TA is interview. Either as a questionnaire or a face to face interview. However, TA is often referred to as the usability method. In a survey of methods and techniques used among HCI practitioners in Denmark (main body of respondents) and researchers (about 25% of respondents) TA came out as the single most frequently applied techniques in testing (Clemmensen and Leisner 2002). TA is seen as a straightforward technique, ready to use with proper handling (Hackos and Redish 1998, Molich, 1994), and has been given the credit of simplicity (Dix, Finlay, Abowd and Beale, 1997). Especially Jakob Nielsen has been a tireless promoter (1994, http://www.useit.com). It has the interest of the IT and media industry because it requires few user tests (5-8 users), it promises instant results and it may be used by non-usability specialists. But more than anything, it is cost effective as it does not require acquisition of expensive hardware and software. However, it has been pointed out that TA suffers from too many and unclear names which come with too many variations in the actual technique applied, hence the methodology has been questioned (Nielsen, Clemmensen and Yssing 2002a).

The understanding embedded in most studies is that the techniques allows us access to the cognitive processes, to mental behaviour and gives us insight into thinking. By recording the verbal protocol, you will be able to "…detect cognitive activities that may not be visible at all" (Hackos & Redish 1998, p. 259), and identify the cognitive processes responsible for users behaviour (Karsenty 2001). But caution has been voiced because the technique puts a cognitive load on the user, which may interfere with the cognitive requirements of the interaction hence disturb the task.

The HCI Research Group at Copenhagen Business School has focus on methods and techniques for analysis, design, test and evaluation, and a pre-condition in our work is that Micro and Small and Medium size IT-Enterprises (Micro/SME) - with or without usability labs - need cost effective usability techniques which give them access to user's mind. The paper shows some of the steps we been through in our work with techniques which will allow us to test not only functionality but also aesthetics and pleasure and at the same time be costs effective. The paper is organised such that I start out with introducing TA. This is followed by critical reflections arguing that TA does not enable testing of multi-modal interfaces where the visual design and the pleasure of interactions are essential features. I then turn to eye-tracking as it promises access to user's visual perception. Eye-tracking is described, followed by critical reflection on the high cost of acquisition and in use. I discuss the data which eye-tracking enables – and ask rhetorically what it is that eye tracking give us access to – pointing out that it is not the mind. In a final step I introduce cursor tracking

with interface capture and argue that combined with participatory analysis, it may be a cost effective usability testing which gives access to users` minds.

THINK ALOUD

In the classic text on protocol analysis from 1984 Ericsson and Simon discussed the use of introspective data in the study of task directed cognitive behaviour. They reinstated verbal data as a valid resource for understanding human cognitive processes. Their understanding was that most performance measures rely on responses that are psychologically indistinguishable from a verbal report, because some kind of verbal reporting is usually necessary to understand people's actions, even in very simple tasks.

Ericsson and Simon distinguished between three kinds of cognitive processes in their model;

- *Talk Aloud* is direct oral expressions of thoughts which already exist in verbal form
- *Think Aloud* is verbalisation of a sequence of thoughts, that are held in memory in some other form, e.g. visually
- *Retrospective verbalisations* of retrospective reports or thoughts not held in short term memory, i.e. explanations and descriptions.

They argue that a sentence is the verbal realisation of thought. The assumption is that everything we know has, at some point, gone through our short-term memory (STM), and we have been conscious of it. We can verbalise what we are learning while in the process of learning, and we can verbalise what we know if questioned shortly after the process of learning has taken place. This is because it is still retained in our short-term memory (talk aloud and think aloud). However, if there is a time span between learning and being requested to recall, we will produce descriptions and explanations (retrospective verbalisations) - not a report of our immediate thought, because the information from STM is lost. In their pursuit of verbal data, Ericsson and Simon were only interested in Talk aloud and Think Aloud, whereas retrospective verbalisations were considered error prone due to the time lap and the reliance on users recall.

Getting access to users´ thoughts?

It has been argued that concurrent verbalisation is problematic when the task involves "a high cognitive load, when the information is difficult to verbalise because of its form…" (Branch 2000), that TA adds strain and cognitive load on the users (Preece 1994) that users have difficulties in speaking and to speak aloud feels awkward (Preece, Rogers and Sharp 2002). Silence is the likely outcome of the situation, hence the need for the investigator to encourage the user to "keep talking".

But what is it we get access to when asking users to think aloud? Does it really give us access to what goes on in people mind? Interestingly, there seems to be a lack of empirical research on users experience with using TA What do users think of TA, how do they feel, how do they experience it? Teaching graduate computer science students the TA test techniques, and requiring them to reflect on their experience raised a number of issues. Students complain that 1) they think faster than they can speak, 2) thought processes are much more complex than can be verbalised, 3) having to think aloud interferes with their interaction with the interfaces and the task and 4) thinking aloud does not come naturally. (Nielsen, Clemmensen and Yssing 2002a).

This led us to question the assumption that performance measure have to rely on some kind of verbal data, and that a sentence is the verbal realisation of the thought (Nielsen, Clemmensen and Yssing 2002b). The sentence that the user speak is a verbal realisation of thought, but there is not a 1:1 relationship between thoughts, actions and the spoken words. Besides the user is interacting with net based multi modal interfaces. Colours, layout, forms, animations, video clip and endless jumps through links all interact and it is visualisations which is the main feature. Hence the interaction is mental and based in visual perception, and thoughts are not mainly verbal and directly accessible in oral speech, but percepts which are, to a large extent, tacit (Polanyi 1967).

Using TA requires the user to shift focus in attention from giving sense to that which is perceived and does not exist in verbal form - to that of constructing sentences or words, and then expressing them aloud. TA requires perception and actions to be transformed to talk. Even if the speech is immediate and runs concurrently with the thoughts – user's attention has to shift focus from understanding to verbalisation (Nielsen and Yssing, 2003). As a consequence the process of understanding is interrupted, because attention keeps changing object and TA may result in verbal overshadowing (Schooler, Uhlsson and Brooks 1993).

But if user's visual perception and action are beyond words, how can usability testing then be conducted? Eye-tracking may be a solution because eyes can be observed and their movements registered.

EYE TRACKING

The Eye-tracking technique seems to take us beyond the verbalisation problem as it captures the visual interaction. It builds on a mind-eye hypothesis and allows us to follow the visual fixations and scan-paths of the user. Our interest is the way the user´s eye travels around the graphic dynamic interfaces, the actions of the user (the navigation) and the way the user experience the interaction: What does the user see, why does the user do what she does and what does she think? Eye-tracking captures a user's focus of visual attention on a visual display unit – through special hardware and software. It gathers x/y location and pupil size/border line information. Especially the jerky movements of the eyes (saccades) which are followed by fixations (x,y location) and combined into scan-paths, and the smooth pursuit of eyes tracking slow moving objects are of interest to usability testing (Goldberg and Wichansky, 2003). Generally speaking there are two way of conducting eye-tracking. One is the well known head mounted system with cameras that the user has to wear. One camera is showing the scene the user is looking at, the other camera is tracking the eye movements. The other eye tracking system is a remote system where the user works directly on the work station, and a camera lens, mounted besides or under the computer, is focused upon the user's eye tracking the pupil, most often with an infrared source. (Goldberg and Wichansky 2003, Ellis and Candrea, 1998, Heyhoe, Shrivastava, Mruzcek and Pelz 2003).

Eye tracking has been used – mainly experimentally - by HCI experts to investigate cognitive workload and scanning behaviour. Salvucci (1999) traced eye movements and argues for an analysis technique: fixation tracing, based on which intent may be inferred. Eye tracking has been used for investigating interface architecture and screen design, e.g. investigating the primary attention focus of the user with the aim of informing design regarding the positioning of visual feedback on the screen. (Rauterberg and Cachin 1993). Ellis and Candrea (1998) used eye tracking to test a website with a two column lay-out with both text blocks and images. Links were embedded in the text blocks, but also images could be links to video sequences. They redesigned the web page in three variation: One version had many links, in the second version they replaced graphics with text blocks and in the third version they made the page look like a book page. They name it "dense-text". Their analysis of eye movement tracking showed that the dense text version scored highest on their usability test.

Critical Issues in eye-tracking

Applying eye tracking technique to usability testing has raised several issues. Whether head mounted system or remote eye tracking system, the user is required to maintain relatively stable head position. Head movements during tests require recalibration, and users have difficulties in keeping their head still, hence it is recommended that calibrations are conducted multiple times during a test session, even "recalibration every few minutes" (Goldberg and Wichansky 2003). There are problems with pupil/borderline registration because the pupils contract and expand in response to light – and the interface constantly changes. Besides there are large individual differences in eye tracking results, users with glasses and contact lenses are often excluded, and if the difference in eye colour is subtle, it may cause failure in the eye tracking. Even though some analysis are done by the computer software, the raw data are "usually aggregated off-line by the investigator into meaningful behavioural units of fixations and saccades – and the amount of data is enormous and the task extremely time consuming. Caution has been voiced about trusting the software calculations too much, "the investigator is strongly encouraged to review the (software) created fixations against images of viewed displays to ensure that the fixations are valid". (ibid). Also the cost of acquiring, learning to operate and the maintenance of an eye tracking system have to be considered. Prices range from just around 18.000 Euro to 100.000 Euro for a complete eye tracking system.

As a consequence there is an interest in testing other tracking systems. In an experiment where the goal was to compared hardware eye-tracking with their "poor man's eye tracker tool" Ullrich and Melis (2003, 2002) got around the heavy expense problem. Their poor man solution was to divide the screen into areas which were blurred, but would be activated by mouse pointer moving into an area and to track mouse movement. They claim that their tracker system and the hardware eye-tracking system yielded similar results in a study they conducted, and summarises that their system is "an easy-to-use, inexpensive and reliable alternative to hardware eye tracking".

With their conclusion they touch upon a serious obstacle for eye tracking. The hardware is expensive, too expensive to acquire for small research units and usability labs. The IT and media industry in Europe has few large companies. In Denmark it is characterised by Micro/SME. It should be kept in mind that micro

enterprises are less than 10 employees, small enterprises are between 10-49 employees and medium enterprises are 50-250 employees. Two thirds of the European labour force is employed in Micro/SME and the average is around six employees (for large companies the average is only 1000 employees) (http://europa.eu.int/scadplus/leg/da/lvb/n26013.htm 040604). They cannot afford usability labs. Besides, when it comes down to the hard negotiations with the clients for contracts, the first place to cut expenses is usability testing, making the need for cost effective high quality usability tests a hot desire.

CURSOR TRACKING AND PARTICIPATORY ANALYSIS – a discussion

Cursor tracking may be a cost effective solution. Cursor tracking is inexpensive to acquire (some are free downloads), easy to install, data collection is automatic, unobtrusive and varied. When Chen and Andersen (2001) wanted to prevent interruption of experiments caused by the need for recalibrations of the eye tracking system, they decided to use a mouse-tracker in their experimental study on cursor/gaze correlation on a computer screen during web browsing. They suggest that the cursor/gaze relationship will vary under different conditions. Byrne et all (1999) has shown that mouse movement strategies were both 1) wait until target is found and trail the eyes with the mouse and 2) mouse movements trail the saccade in regular fashion but occur before the target has been located. This finding indicates that eye/mouse correlation does not always follow suggesting that users need to learn the technique of correlating.

Naming it eye/cursor movements, or eye-mouse correlation escape the fact that it is the hand the user has to move – represented on the interface through the cursor, hence coordination with the eye. But the actions has to be carried out by the hand and this competence has to be acquired. The following is a suggestion for an iterative progressive process of learning which the user may be taken through, before testing with a cursor tracking/interface capture system:

- *Direct coordination eye-hand*: the aim is to introduce the visual reading approach. This is done by placing, in front of the user, a pen and an image which has a transparency mounted on top. The user is asked to let the pen follow her/is eyes as they scan the image.
- *Semi-direct coordination eye-hand*: the aim is to reinforce the experience of visual reading, but with a semi-direct coordination between hand/eye. This is done by projecting the image on wall in front of user. User has to do the same as before: let pen trail eyes, and is asked in addition to mark starting point, and fixation points during the tracking on a transparency which is placed in front of her/im.
- *Indirect coordination eye-hand*: this is visual interaction directly with a computer interface and automatic recording of the way cursor is being moved, cursor click and the screen (cursor tracking and browser capture) (Nielsen and Yssing 2003).

Though the aim with the progressive introduction to ”mouse tracker” is a learning process for the user to go through, we suggest that the data from the exercises may give a tentative view into the question of eye/cursor correlation. The direct coordination of eye-hand may give access to data in the form of transparencies showing reading pattern. This data allows for a very initial quantitative analysis of correlations across tester population. How is the eye movement pattern? Are there some areas of the design which are not visited at all? Are there some areas where the eyes often return to?
With the semi-direct coordination of eye-hand the data may give access to quantitative analysis across tester population with fixation and scan paths. Here it may be possible to see e.g. if the tester population scan according to the intentions of the designed interface.
With the last step – the indirect coordination of eye-hand – the data registration becomes automatic. The use of software to capture cursor movement and browser allows for collections of very detailed data. Does the user click with the left or the right mouse, how long time is the cursor fixated in a given point, how long are the saccade movement of the mouse, where does the cursor come to rest after the saccade movement etc.

Capturing minds

Ellis´ and Candrea`s (1998) use of eye-tracking showed that their dense-text layout scored highest on their usability test (efficiency and effectiveness). But they conclude, somewhat surprised, “ … despite it’s potentially superior usability, dense-text was the lowest rated of all the lay-outs by our testers”. This data was not registered by the eye-tracking system, but was collected after the test when the users were asked to rate the different interfaces.

The surprise that Ellis and Candrea voice point to a serious problem with eye-tracking, it does not give access to mind. Interestingly, the title of their paper is “Windows to the soul?”, quoting the French poet Guillaume de Salluste of Bartas (1544-90). The overture their paper starts with is “eyes reveal a great deal about a person’s feeling and behaviour”. They ask the question, but they never answer it. Registration of eye movement do not tell us anything about the soul. Eye-tracking only register movement, behaviour – not

what goes on inside the human being. It does not give us access to mind. Besides, cursor motion does not necessarily track where the user is looking, s/he may forget to move the cursor because something on the multimodal interface catches her/his attention, and the capturing does not tell whether s/he is contemplating, reading, taking pleasure in the meeting of two colours or simply daydreaming. But their data also show that we need to go beyond the mere cursor/interface tracking and follow up with further investigations.

Retrospective verbalisation and participatory analysis
Though the hypothesis lying behind is the eye-mind assumption – we only have logging of cursor, fixation of cursor, paths of cursor, saccades of cursor and the different interfaces capture. We do not have access to mind and we do not know what the users feel, think, experience. This is where the third level in Ericsson and Simons model may be of help. That is the retrospective verbalisations which are thoughts not held in short term memory, i.e. explanations and descriptions. The authors argument is that if there is a time span between learning and being requested to recall, the user will produce retrospective verbalisations - not reports of their immediate thought, because the information from STM is lost. And retrospective reporting is more error prone because it relies on user's subjective recall – not on "hard facts", and subjective verbal data are not considered valid.

However, the working of user's mind cannot be observed or registered. The only way to get access to user's experience is by asking how the user experience the interaction: What does the user see, why does the user do what s/he does and what does s/he think? One of the unique advantages with cursor tracking and interface capture is that there is a recording of the actual actions of the user. It can be replayed and shown to the user. What the user sees is what s/he saw while working on the test, only the screen image includes cursor movement. The recording of the screen and mouse can be stopped/resumed at any given point. During the stops a recording of the user`s comments and reflections unfolding as a consequence of the probing continues to be recorded on top of the frozen image. Thus, in the final analysis, the investigator is in possession of an uninterrupted recording of user`s interaction with the interface during the test, and a recording of the user`s interaction with the interface with interruptions, but with voice over.

Mindtape – a participatory technique
Investigating a group of users' experience with a CSCW prototype, video recordings of distributed collaboration was used to explore, together with users, what went on in their minds. When the tapes were analysed initially by the researchers, some of the events made no sense and the idea to present the sequence to the users for clarification occurred. The outcome was a surprise. The viewing opened up for – at times – elaborate explanations and comments to the thought processes behind the behaviour we were able to observe on the tapes (Nielsen and Christiansen, 1996). When users heard and saw the unfolding of the dialogue between themselves and their colleagues, the interface and the data they worked with on the screen, their memory seemed to be triggered in a very special way. They seemed to recall, in extremely detailed grain, what they did, and why, what they expected to happen, what they thought when a visual image appeared on the screen, why they juxtapose another image etc. They seemed capable of making internal thought processes explicit, and it was almost as if a "Mindtape" of their tacit inferences were being replayed.

Such detailed descriptions of thought processes cannot be captured through more traditional methods as e.g. Thinking Aloud. Obviously a detailed analysis of a TA video recording, followed up with an in-depth inquiry will – to some extent – be able to produce a verbalization of some of the tacit inferences. However, as has been argued, thinking aloud does not come naturally, but imposes constraints on the creative thinking processes, because the user cannot flow with the ideas occurring, but has to constantly transform them into words. Besides, many of the thoughts cannot be expressed in real time while simultaneously interacting with the computer and the files in order to do the task. These thought processes take place much faster because they lie underneath or surround the language (Kirkeby 1988).

Closing comments
The capture of interface with cursor tracking combined with Mindtape seems promising because the processes of insight that runs associatively while the user interacts with the computer application may become partly explicit during replay without being a total subjective recall. It is specific for Mindtape that the replay triggers a running commentary at the same time as the events take place on the capture. The captured images may enhance the user's access to, and help the user recall, the thought processes that took place, and this verbalization flows easy with the actual sequence of events structuring – not the users memory. This is important, a Mindtape is structured by the actual user-computer inter-actions as they unfolded during the test session and were recorded. It is not the users memory which controls the recall, but the actual events. Tracking cursor and capturing interface combined with participatory data analysis seems

promising, and in the future this combination needs to be explored in order to throw light upon the question: Is this approach cost effective and does it give access to user's mind?

References

Boren M. Ted and Judith Ramey(2000) Thinking Aloud: Reconciling Theory and Practice, |*IEEE Transactions on Professional Communication,* vol. 43, no. 3, September , p. 261-278

Branch, J.L.(2999) Investigating the information-seeking processes for adolescents, *Library & Information Science Research,* vol.22, 4, 371-392

Bruner, Jerome(1990= Acts of Meaning, Harvard University Press, Cambridge

Byrne Michael D., Anderson John R., Douglass Scott and Michael Matessa (1999) Eye Tracking the Visual Search on click-Down Menus, Proceedings of HI99, Pittsburgh, 402-409

Chen Mon-Chu, Anderson John R.and Meyeong-Ho Sohn(2001)What can a mouse cursor tell us more? Correlation of eye/mouse movements on web browsing, Proceedings of CHI 2001, Short Talks, 281-283

Clemmensen, T and P. Leisner(2002) Community knowledge in an emerging online professional community, Proceedings of IRIS25, Denmark,

Dix A., Finlay J., Abowd G. And R. Beale(1997) Human-Computer Interaction, Prentice Hall, 1997

Ellis Steve and Ron Candrea(1998) Windows to the soul? What eye movements tell us about Software Usability, Proceedings of the 7th Annual conference of the Usability Professional Association, Washington DC, 151-156

Ericsson, K.A. and Simon, H.A. s984) Protocol Analysis. Verbal reports as data, Cambridge, Massachusetts

Goldberg, Joseph H. And Anna M. Wichansky(2003) Eye Tracking in usability Evaluation: A Practitioner's Guide, in Hyöna J., Racdach R. And Deubel H.(eds.) *The mind's eye: Cognitive and Applied aspects of eye movement research*, Elsevier Science BV, chapter 23, 493 - 516

Hackos, J.T. and Redish, J.C.(1998) User and Task Analysis for Interface Design, Wiley, USA

Hayhoe Mary M., Shrivastava Anurag, Mruczek Ryan and Jeff B. Pelz(2003) Visual memory and motor planning in a natural task, *Journal of Vision* (2993), 3, 49-63

Karasti, Helena (1996), in Workshop Tacit Knowledge: Iceberg in Collaborative Design, In *Proceedings of CSCW'96.* Cambridge, Mass. November 16-21.

Karsenty, L.(2001) Adapting verbal protocol methods to investigate speech systems use, *applied Ergonomics*, vol. 32, 1, 15-22

Kirkeby, Ole Fogh (1988): Kroppens tanke. Om kunstig intelligens – det umuliges kunst. Samfundslitteratur, København

Molich Rolf (1994) Brugervenlige edb-systemer, Nyt Teknisk Forlag, København

Nielsen, Jakob: http://www.useit.com/

Nielsen, Jakob(1994) Estimating the Number of subjects Needed for a Thinking aloud Test, *International Journal of Human-Computer Studies*, 41, 3, 385-397

Nielsen, J. and Christiansen, N.(1996), Video as a tool for Data Capturing and for Analysis, *in Dialogue Design – Methodological Considerations in the MANICORAL-Project*, (eds.) Dirckinck-Holmfeld, L., RE1006, Deliverable Number 3.1.3.

Nielsen Janni and Nina Christiansen(2000) Mind tape: A Tool for Reflection in Participatory Design, in Proceedings, Conference Participatory Design, New York 2000

Nielsen Janni, Clemmensen Torkil and Carsten Yssing(2002a) Getting access to what goes on in people's Heads? NordiCHI proceedings, Denmark, 101-110

Nielsen Janni, Clemmensen Torkil and Carsten Yssing (2002b) People's Heads – People's Minds, Proceedings of the APCHI 2002 (5th Asia Pacific Conference on Computer Human Interaction): User Interaction technology in the 21st Century, 2002, China, Science Press, Beijing (897-906)

Nielsen Janni and Carsten Yssing (2003) Getting beyond the disruptive effect of Think Aloud, in Hertzum Morten and Simon Heilesen(eds.) *Proceedings of the third Danish Human-Computer Interaction Research symposium.* Datalogiske Skrifter, Roskilde University, 67-71.

Preece J., Rogers Y. And Sharp H.(20029 Interaction Design: beyond Human-Computer Interaction, John Wiley & Son

Polanyi, Michael(1967) Logic and Psychology, *American Psychologist*, no.23, 27-43

Rauterberg Matthias and Christian Cachin(1993) Locating the primary attention focus of the user, in Grechenig T. And M. Tscheligi(eds.) *Human Computer Interaction* (Lecture Notes in Computer Science 733, 129—140) Berlin, Springer

Salvucci Dario d.(1999) Inferring Intent in Eye-based Interfaces: Tracing Eye Movements with Process Models, Proceedings of CHI 99, Pittsburgh, USA, 254-261

Schooler Jonathan W. Uhlsson Stellan and Kevin Brooks(1993) Thoughts beyond Words, *Journal of Experimental Psychology,* vol. 122, 2, 166-183

Schroeder Will(1998) What is Eye-Tracking Good For? Original published 09/01/1998, http://www.uie.com/articles/eye_tracking_benefits/040302

Teague Ross, De Jesus Katherine and Marcos Nunes-Ueno(2001) Concurrent Vs. Post-Task Usability Test Rating, in Proceedings of CHI 2001, Short Talks, 289-291

Ullrich Carsten and Erica Melis(2002) The Poor Man's Eyetracker Tool of ActiveMath. Proceedings of the World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education (eLearn-2002), *International Journal on E-Learning*, 2002, Vol. 1, pages 2313-2316

Ullrich Carsten, Wallach Dieter and Erica Melis(2003) What Is Poor Man's Eye Tracking Good For?, 17th Annual Human-Computer Interaction Conference, 2003, no place, no publisher, no page references

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