

Analysis of Handwriting and Eye Movements: The Eye and Pen project



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A glimpse of history

Interest for handwriting processes study in real time emerged in the early 80's mostly within the Nijmegen Institute for Cognition and Information (NICI) group (The Netherlands) with Teulings, Maarse, van Galen and Thomassen.

In the late 80's the **European Association for Research on Learning and Instruction (EARLI)** sets its **Special Interest Group-Writing**.

The 1st Conference of SIG Writing was held in Padova (Italy) in 1988.

Poitiers' psychology laboratory has been involved in this field since this time.

Required tools were few, so home-made software was built to record handwriting pauses in real time:

Espéret E., Passerault J.-M. (1991). On-line study of planning processes in writing texts on a digitalizing tablet: Methodological and theoretical issues. *SIG Writing, 4th EARLI Conference, 24-28 august, Turku (Finland)*.

To be able to record the whole writing dynamics, a new software was built:

Chesnet, D., Guillabert, F. & Esperet, E. (1994). G-Studio: un logiciel pour l'étude en temps réel des paramètres temporels de la production écrite. *L'Année Psychologique, 94, 283-294*.

G-Studio was an MS-Dos based software, able to locate, tag and measure pauses, as well as to compute some tracing dynamics parameters.

The screenshot displays the G-Studio software interface. The main window shows a hand-drawn diagram of a submarine volcano. The diagram is titled "Le volcan sous-marin" and includes labels for "Source chaude", "MAGMA", and "Infiltration de l'eau". Three numbered circles (1, 2, 3) are placed on the diagram to indicate specific points of interest. A mouse cursor is visible near the bottom right of the diagram.

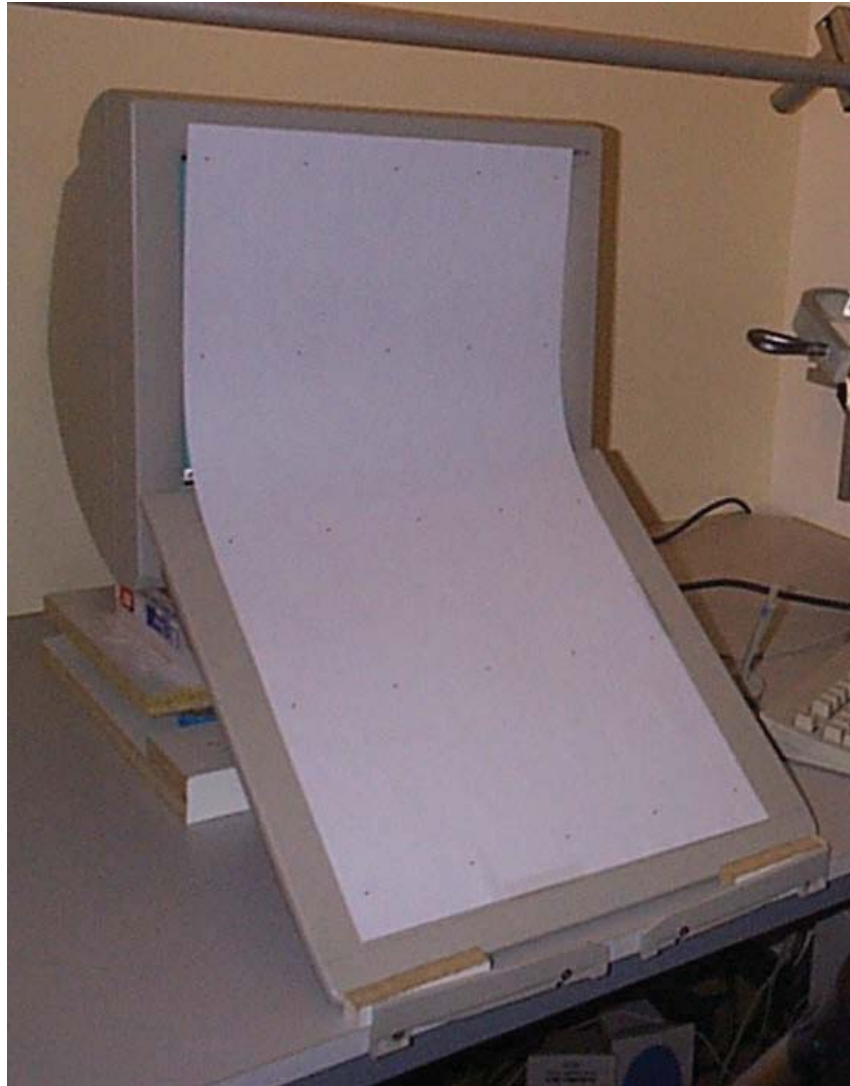
On the right side of the interface, there is a panel titled "VOLCAN_1" containing the following information:

- Pause number: n°230
- Pause duration: t:3446
- Pause tags: A list of tags from 12 to 115, with tag 13 highlighted.
- Buttons: inPrinter, Options, Aide, Zoom, Charger, Sauver, and Quitter.

Two blue callout boxes provide additional information:

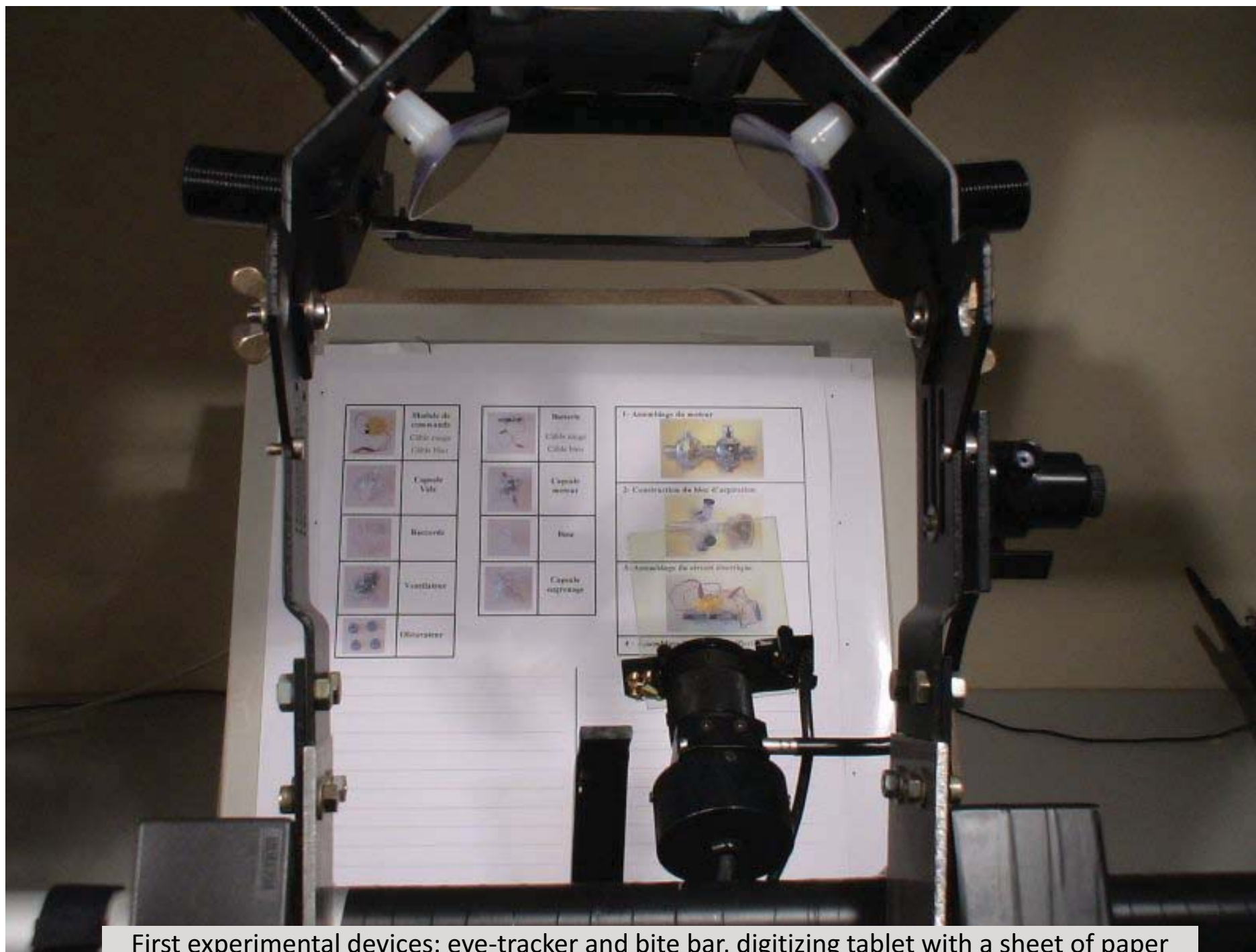
- "Pen was lifted up here" points to the start of a line in the diagram.
- "Pen was laid down here" points to the end of a line in the diagram.

A new version supporting MS-Windows and an eyetracker was needed.



Eyetracker calibration (on a sheet of paper)





First experimental devices: eye-tracker and bite bar, digitizing tablet with a sheet of paper

With hardware evolution, implementation became more friendly...



... and can be used with children



Eye and Pen supports a wide range of LCD and classic tablets, as well as TabletPC



What tablet for which usage ?

Liquid Crystal Display tablets:

- record eye movements while writing / drawing
- manipulate writing feedback (time, size, masking, etc.)



Classic tablets:

- more “ecological” context (pen and paper)
- Higher sampling rate (200Hz) and resolution



Writing may be Shown / hidden on screen during recording to manipulate visual feedback to participant

“Natural” feedback can be ensured by using inking pen and sheets of paper, on a classic tablet



Eye and Pen supports eyetracking devices

- EyelinkII and Eyelink 1000 (S.R. research, Ltd.)



- i-ViewX HED (SensoMotoric Instruments GmbH, S.M.I.)



- ASL 504 (Applied Science Laboratories, A.S.L.)



- EyePuter (Alphabio)



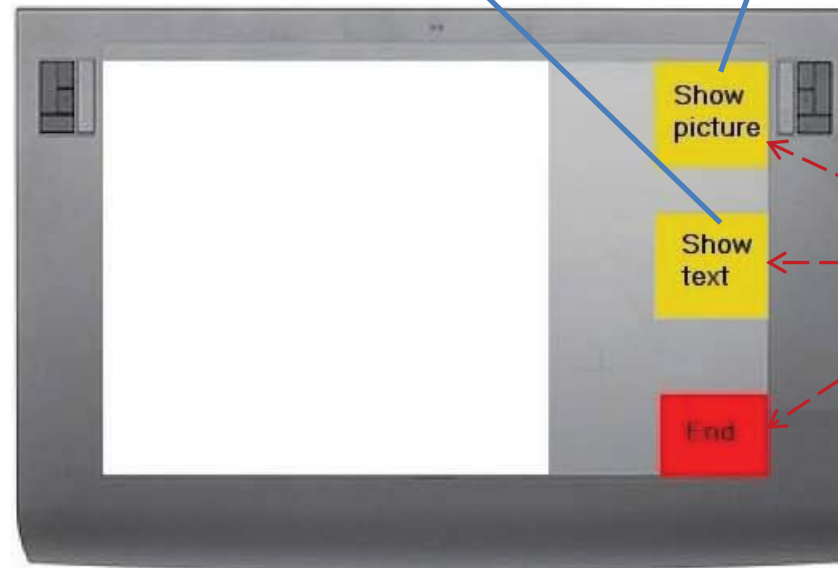
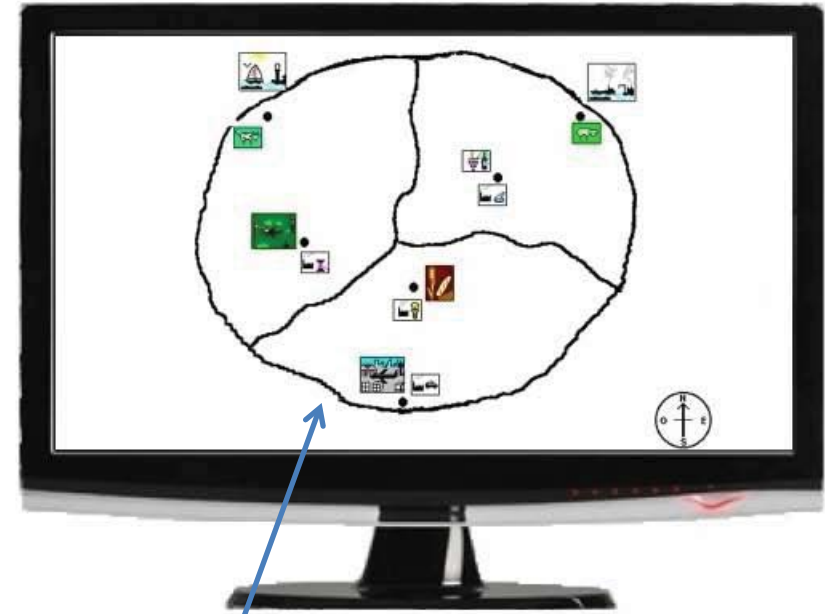
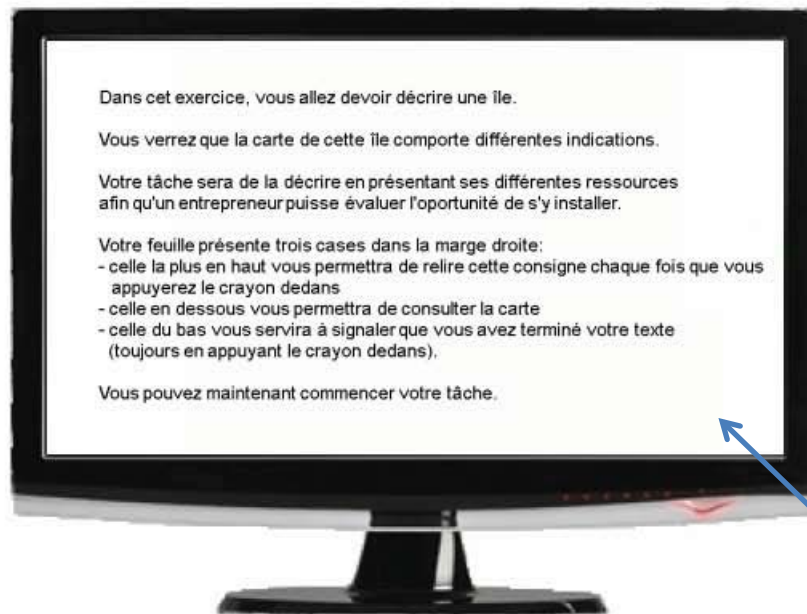
- Tablet (Pen Tracking)

Records pen movement data (even when pen is “in the air”) as if it were eyetracking data.

The logo for FME Pen is centered in the background. It features the words "FME" and "Pen" in a stylized, 3D, grey font. "FME" is positioned above "Pen". A thin, purple, circular line with a slight 3D effect encircles the text. A horizontal grey bar with a slight 3D effect is positioned across the middle of the logo, containing the text "Data acquisition".

Data acquisition

Acquisition with “Simple”



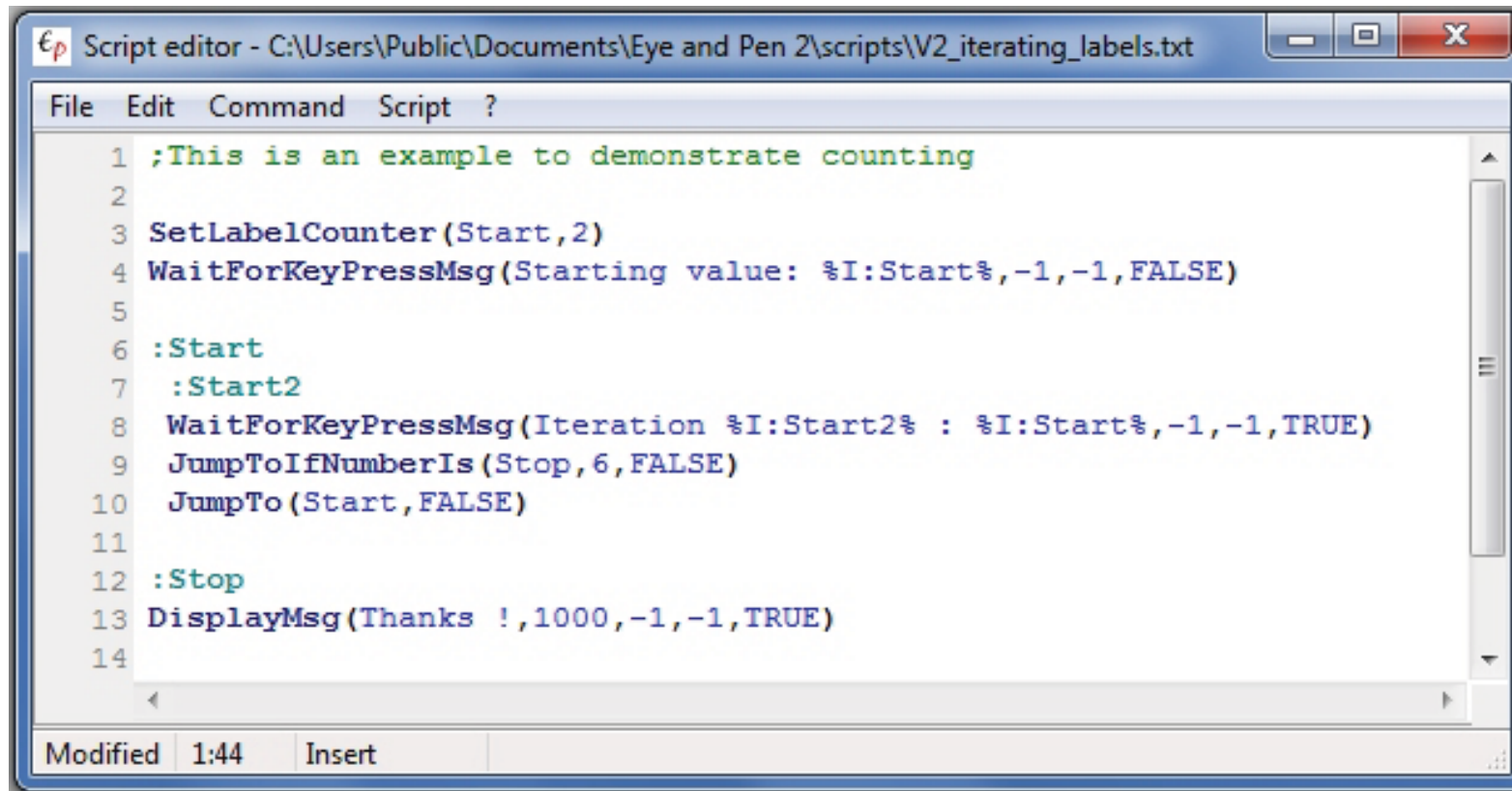
A graphic interface allows to define areas on the tablet that will act as triggers: when the participant will press the pentip into, an associated stimulus will be displayed. Everything is recorded: handwriting, drawing, actions.

No “programming” required.

Scripted acquisition

Eye and Pen has a script language that allows one to “program” an acquisition, when “Simple” is not enough.

A script editor helps to write commands and set parameters.

A screenshot of a Windows-style script editor window. The title bar reads "Script editor - C:\Users\Public\Documents\Eye and Pen 2\scripts\V2_iterating_labels.txt". The menu bar includes "File", "Edit", "Command", "Script", and "?". The script content is as follows:

```
1 ;This is an example to demonstrate counting
2
3 SetLabelCounter(Start,2)
4 WaitForKeyPressMsg(Starting value: %I:Start%, -1, -1, FALSE)
5
6 :Start
7 :Start2
8 WaitForKeyPressMsg(Iteration %I:Start2% : %I:Start%, -1, -1, TRUE)
9 JumpToIfNumberIs (Stop, 6, FALSE)
10 JumpTo (Start, FALSE)
11
12 :Stop
13 DisplayMsg(Thanks !, 1000, -1, -1, TRUE)
14
```

The status bar at the bottom shows "Modified 1:44 Insert".

Basically, script allows:

Manipulate **stimuli**

- ✓ display picture, text file, single line message
- ✓ play sound file, video

Interact with participant (alone or in network managed group)

- ✓ wait for keyboard key presses
- ✓ wait for pen tip to be pressed into specified tablet areas

Manipulate **feedback**

- ✓ mask/unmask display
- ✓ Timeshift writing display on screen
- ✓ shift location of writing display on screen
- ✓ change size of writing display

Setup a **list of items** and its randomization (full or partial).

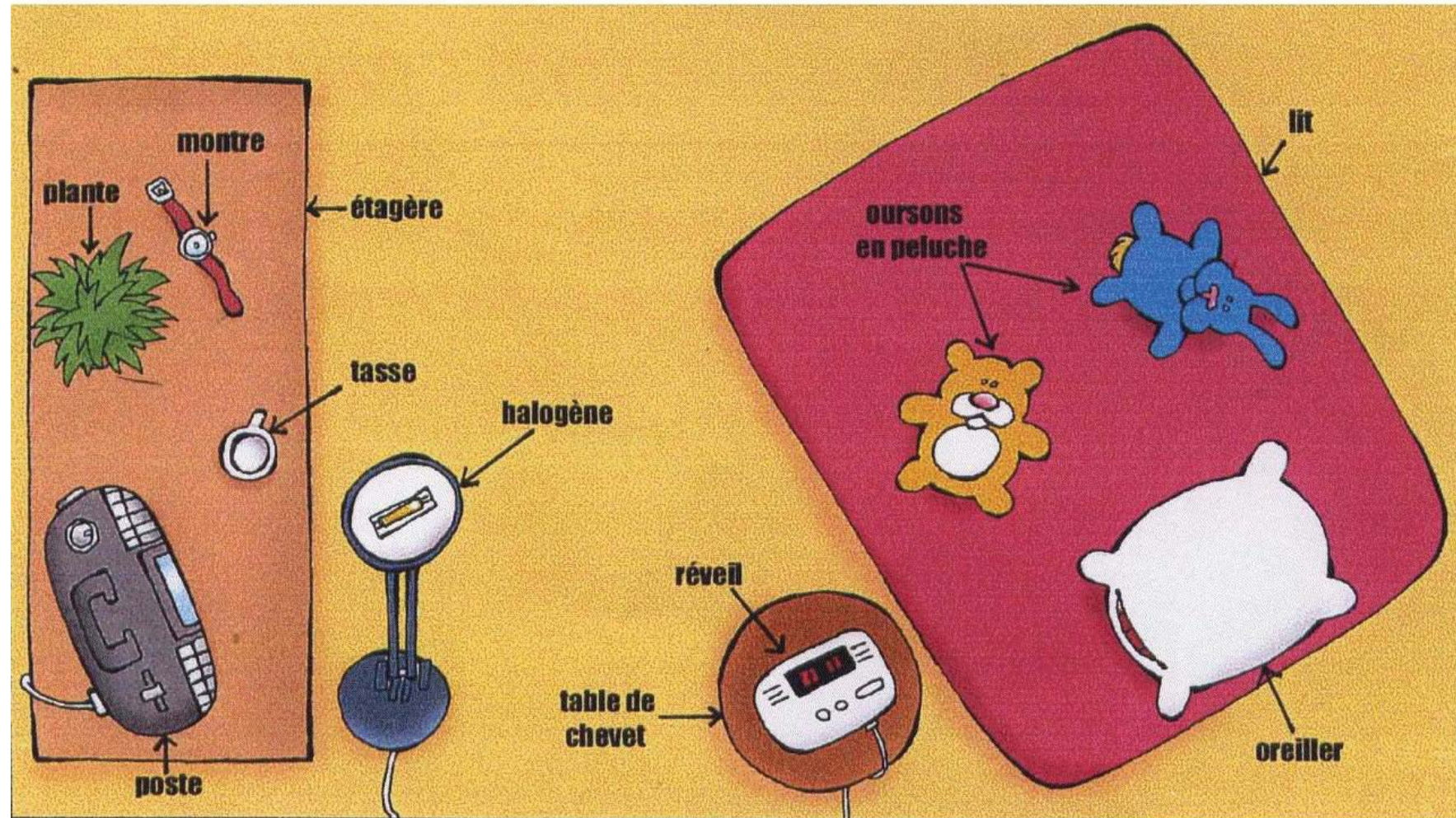
And much more....

The whole set is about 70 commands.

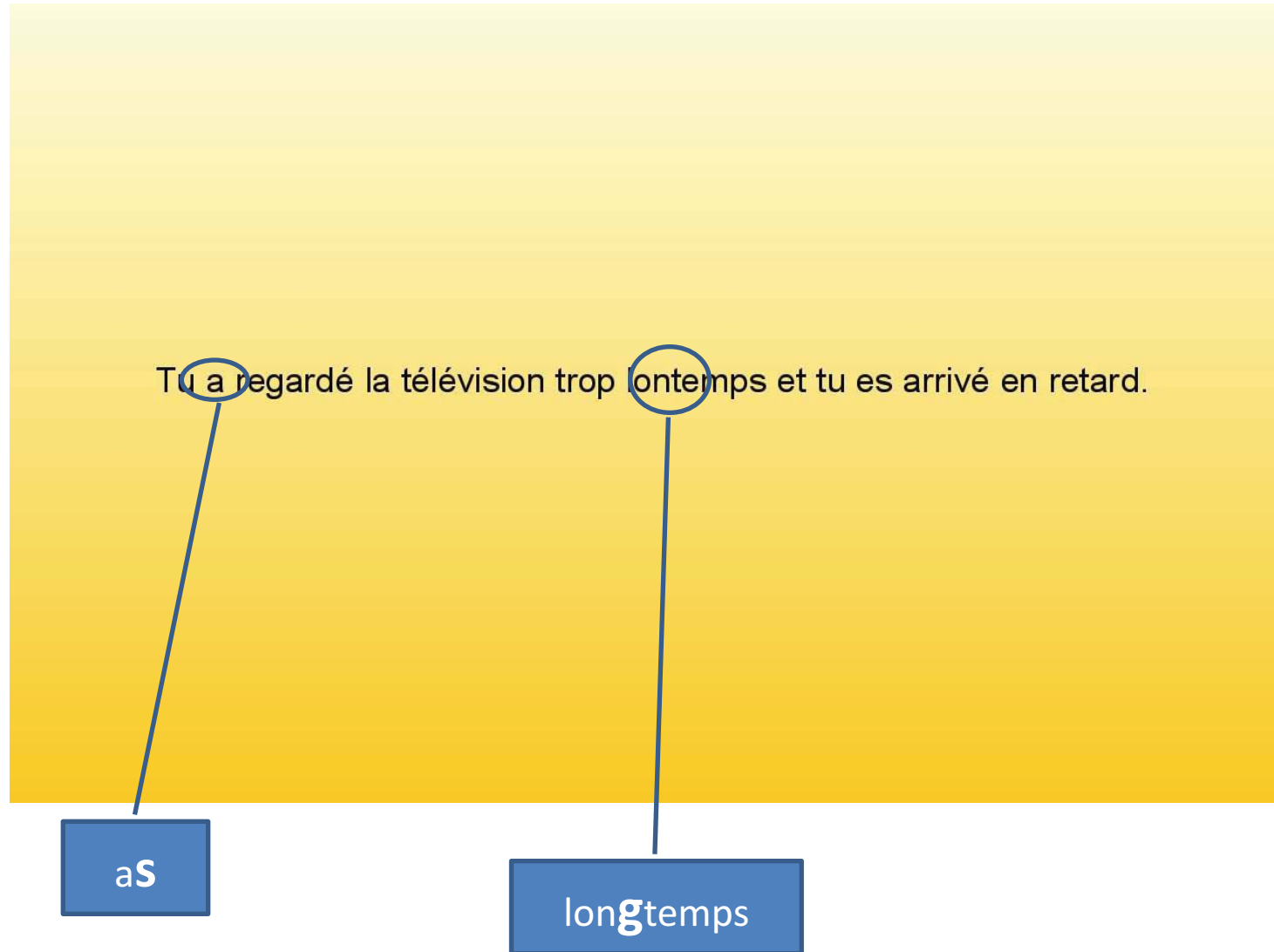
The logo for 'Eye and Pen' is centered in the background. It features the words 'Eye' and 'Pen' in a stylized, cursive script. A large, light gray letter 'Q' is positioned behind the word 'Eye'. A purple circular line with a small gap at the bottom encircles the text. A horizontal gray bar with a slight 3D effect is placed across the middle of the logo, containing the title text.

Examples of experiments

Scene description from a picture



Error detection and correction



copying words

bouffée

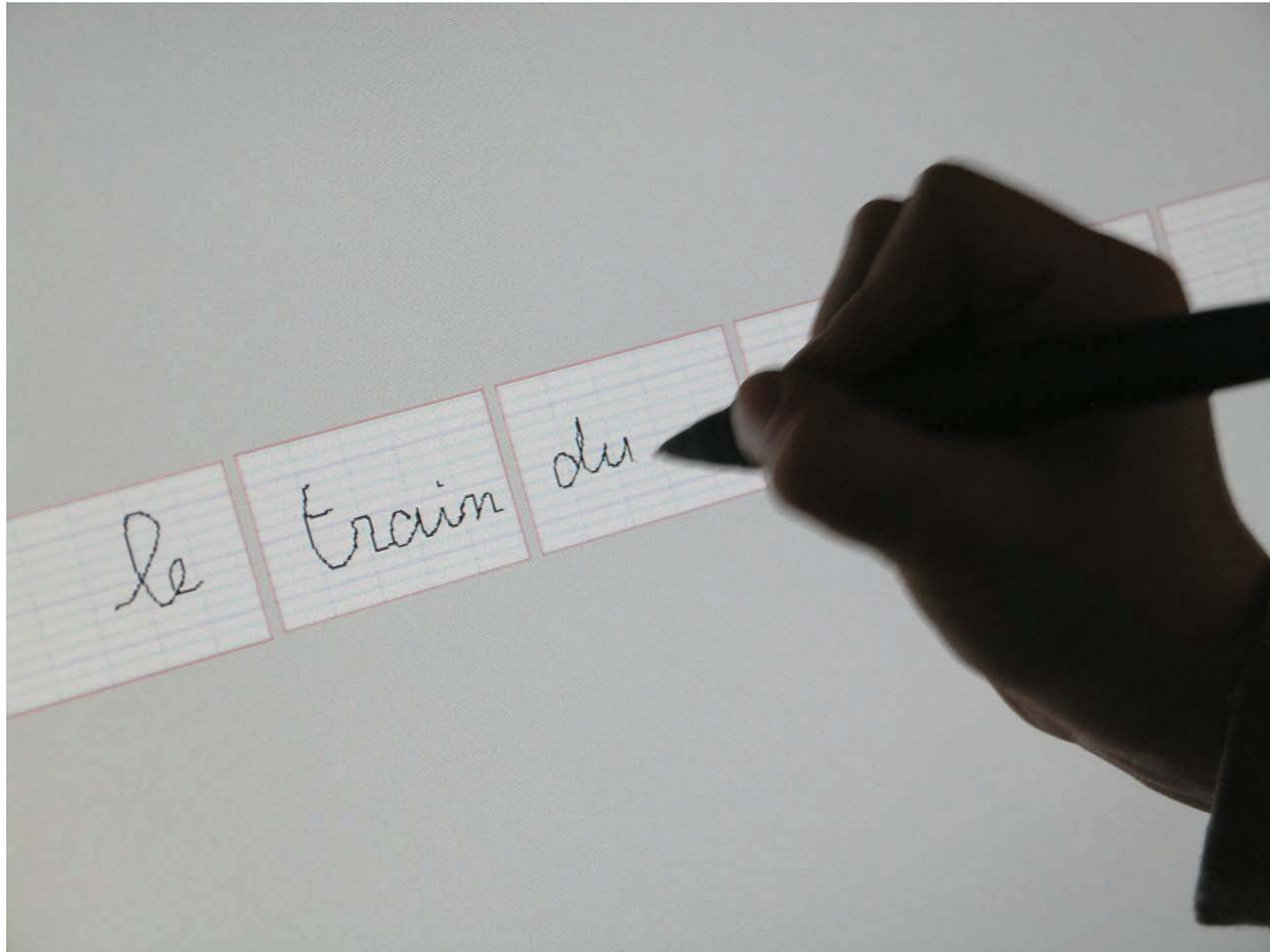
corridor

blockhaus

sixième

FIN

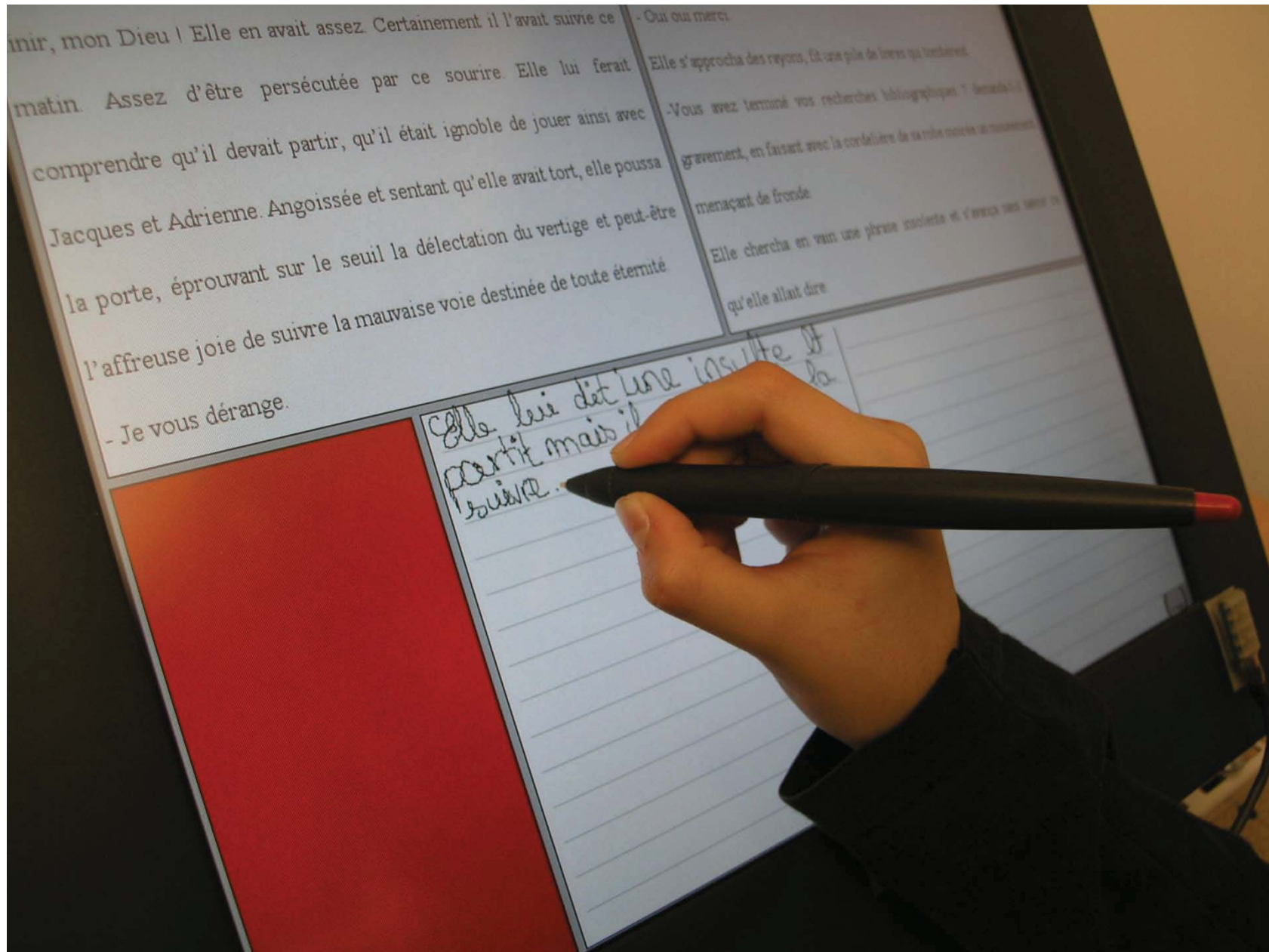
Sentence dictation (here, subject-verb agreement)



3D shape recognition and selection



Continuing a story



Writing with feedback on a masked screen



Writing with unattended speech



Eye and Pen can manage acquisition in group within a dedicated network.

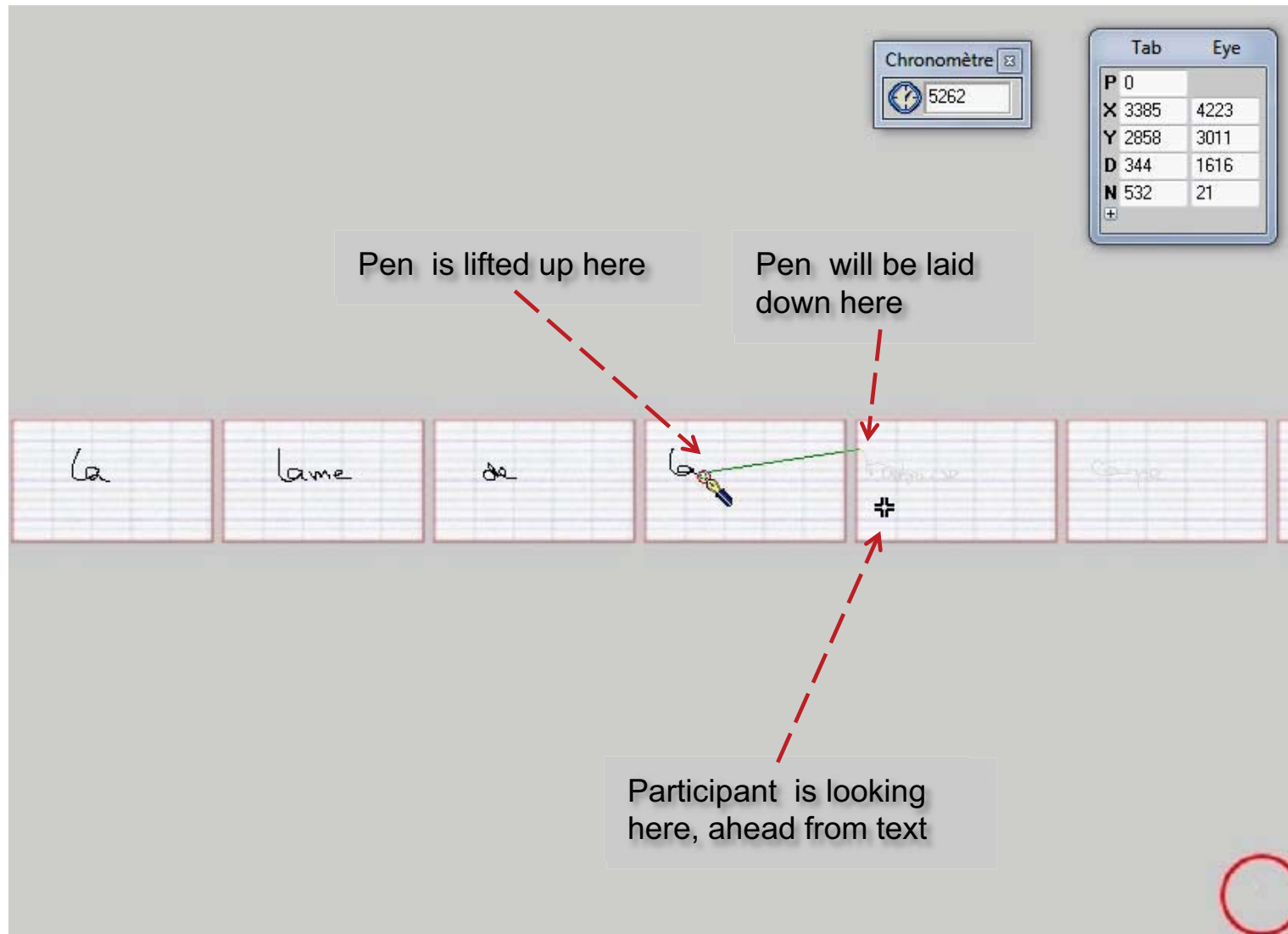


The logo for 'Eye and Pen' is centered in the background. It features the words 'Eye' and 'Pen' in a light gray, cursive script font. A thin, purple, hand-drawn circular line encircles the text. A horizontal gray bar with a slight 3D effect is positioned across the middle of the logo, containing the text 'Data visualization' in a black, sans-serif font.

Data visualization

Eye and Pen can replay data, with behavior “highlighting”:

- a circle located at pause beginning grows with duration
- a line joins the place where pen was lifted up and where it was laid down again



Copy of a pseudo-word

Participant is
looking here...


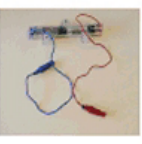
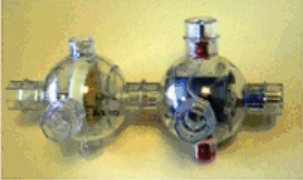

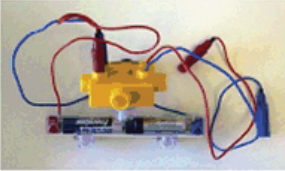


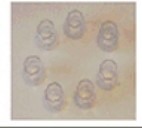




p[#]ricor

p[#]ricor



... and writing here

Eye and Pen has a number of data visualization features

	Module de commande Câble rouge Câble bleu		Batterie Câble rouge Câble bleu	1- Assemblage du moteur  2- Construction du bloc d'aspiration  3- Assemblage du circuit électrique  4 - Assemblage final de la soufflerie
	Capsule Vide		Capsule moteur	
	Raccords		Buse	
	Ventilateur		Capsule engrenage	
	Ob turateur			

⚡

Comment construire un ventilateur :

On commence par le bloc d'aspiration. Prendre la capsule vide, insérer les raccords pour fixer des filtres. N'oublier pas de boucher l'ouverture à l'arrière de la capsule.

Ensuite fixer le ventilateur à cette capsule.


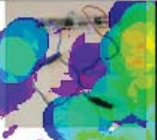
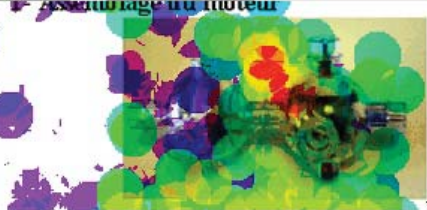
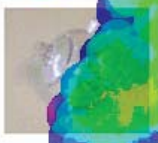



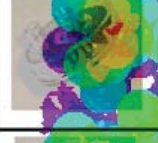
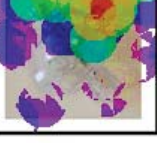

Prendre la capsule engrenage et la fixer au ventilateur, au bout

de cette capsule fixer la dernière capsule moteur. A l'aide des raccords fixer sur le dessus des capots engrenage et moteur la batterie. Et sur le dessus de la batterie mettre le module de commande. Mettre les câbles de la batterie sur la capsule moteur et les câbles du module de commande sur la batterie.

Fin

Participant wrote here

Fixations as heat map

	Module de commande Câble rouge Câble bleu		Batterie Câble rouge Câble bleu	
	Capsule Vide		Capsule moteur	2- Construction du bloc d'aspiration
	Raccords		Buse	3- Assemblage du circuit électrique
	Ventilateur		Capsule engrenage	4 - Assemblage final de la soufflerie
	Obturateur			

Comment construire un ventilateur :

On commence par la buse d'aspiration. Prendre la capsule et, insérer les raccords pour fixer des filtres.

N'oublier pas de boucher l'ouverture à l'arrière de la capsule.









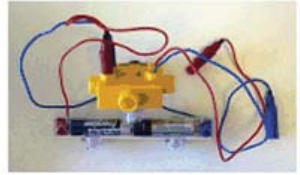



Ensuite fixer le ventilateur à cette capsule.

Prendre la capsule engrenage et la fixer au ventilateur, au bout

de cette capsule fixer la dernière capsule moteur. A l'arrière des raccords fixer sur la dernière capsule engrenage et moteur la batterie. et sur le dessus de la batterie mettre le module de commande. Mettre les câbles de la batterie sur la capsule moteur et les câbles du module de commande sur la batterie.

Fin

Pauses durations as circles (the larger the circle, the longer the pause)

	Module de commande Câble rouge Câble bleu		Batterie Câble rouge Câble bleu	1- Assemblage du moteur 
	Capsule Vide		Capsule moteur	2- Construction du bloc d'aspiration 
	Raccords		Buse	3- Assemblage du circuit électrique 
	Ventilateur		Capsule engrenage	4 - Assemblage final de la soufflerie
	Ob turateur			










Comment construire une soufflerie

On commence par le bloc d'aspiration. On prend la capsule et on utilise les raccords pour fixer les filtres. Ensuite, on fixe la buse transparente à l'extrémité de la capsule. Ensuite, on fixe le ventilateur à cette capsule. Ensuite, la capsule engrenage est fixée au ventilateur au bout


de cette capsule. On fixe la dernière capsule moteur. À l'aide des raccords, on fixe la capsule du moteur à la batterie et on se donne de la batterie, met le module de commande. On fixe la capsule de la batterie sur la capsule moteur et la capsule du module de commande sur la batterie.

Fin

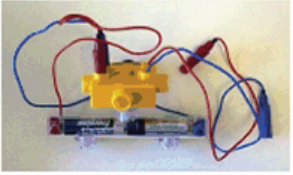
Pauses classified by durations

0 30 60 80 100 120 150 200 400 800 1200 2000 +		Assemblage du moteur	
	Câble rouge Câble bleu		Câble rouge Câble bleu
	Capsule Vide		Capsule moteur
	Raccords		Buse
	Ventilateur		Capsule engrenage
	Obturbateur		

2- Construction du bloc d'aspiration



3- Assemblage du circuit électrique



4 - Assemblage final de la soufflerie

Comment construire un ventilateur.

On commence par le bloc d'aspiration. Prendre la capsule vide, insérer les raccords pour fixer les filtres. Ne pas oublier de boucher les trous de la capsule. Fixer le ventilateur à cette capsule. Prendre la capsule engrenage et la fixer au ventilateur, au bout

de cette capsule fixer la dernière capsule moteur. À l'aide des raccords fixer au dos des capsules engrenage et moteur la batterie et au dos des de la batterie mettre le module de commande. Mettre la cable de la batterie sur la capsule moteur et la cable du module de commande sur la batterie.

Fin

The logo for 'Eye and Pen' is centered in the background. It features the words 'Eye' and 'Pen' in a stylized, cursive script. A large, light gray letter 'Q' is positioned behind the word 'Eye'. A purple circular line with a small gap at the top encircles the text. A horizontal gray bar is superimposed over the center of the logo.

Data analysis

Eye and Pen 2 software interface showing a protocol for assembling a soufflerie (blower).

Module de commande
Câble rouge
Câble bleu

Batterie
Câble rouge
Câble bleu

Capsule Vide

Capsule moteur

Raccords

Buse

Ventilateur

Capsule engrenage

Obturateur

1- Assemblage du moteur

2- Construction du bloc d'aspiration

3- Assemblage du circuit électrique

4 - Assemblage final de la soufflerie

Tab Eye

P	X	Y	D	N
0	0	15240	30707	0
1	0	7620	3372	0
2	0	7620	3372	0
3	0	7620	3372	0
4	0	7620	3372	0
5	0	7620	3372	0
6	0	7620	3372	0
7	0	7620	3372	0
8	0	7620	3372	0
9	0	7620	3372	0
10	0	7620	3372	0
11	0	7620	3372	0
12	0	7620	3372	0
13	0	7620	3372	0
14	0	7620	3372	0
15	0	7620	3372	0
16	0	7620	3372	0
17	0	7620	3372	0
18	0	7620	3372	0
19	0	7620	3372	0

ASSEMBLAGE DU MOTEUR
1- Prendre la capsule engrenage et la placer de sorte que dans l'opération d'assemblage du moteur, le tuyau le plus long se trouve à gauche.

CONSTRUCTION DU BLOC D'ASPIRATION
Trouver à gauche de l'installation - Utiliser des obturateurs pour boucher les tuyaux restant, en prenant soin de garder le tuyau à l'opposé du plus long tuyau disponible, pour embosser le...

ASSEMBLAGE DU CIRCUIT ÉLECTRIQUE
Brancher la batterie de sorte que l'extrémité du câble rouge se trouve à notre gauche. Embosser l'un dans l'autre et attacher le câble source de la batterie sur l'autre.

ASSEMBLAGE FINAL DE LA SOUFFLERIE
Brancher la batterie de sorte que l'extrémité du câble rouge se trouve à notre gauche. Embosser l'un dans l'autre et attacher le câble source de la batterie sur l'autre.

Eye and Pen 2 software interface showing a protocol for assembling a soufflerie (blower).

Eye and Pen has a number of data selection and tagging tools, data exploration tools, segmenting the protocol into sequences, etc.

AOI definition for eye movement data

ACIsujet212 - Eye & Pen 2

Module de commande
Câble rouge
Câble bleu

Capsule Vide

Raccords

Ventilateur

Obturateur

Batterie
Câble rouge
Câble bleu

Capsule moteur

Buse

Capsule engrenage

1- Assemblage du moteur

2- Construction du bloc d'aspiration

3- Assemblage du circuit électrique

4 - Assemblage final de la soufflerie

Visual zones (AOI)

Area of Interest

AOI definition

X1 49 Y1 12952

X2 7471 Y2 14796

Label

Code 14

Add Delete

AOI list

7471	8746	15030	10925	15
7456	10925	15076	12983	16
7471	12967	15274	14811	17
49	8746	7410	10910	12
49	10910	7440	12967	13
49	12952	7471	14796	14
721	1125	2443	8684	1
2458	1125	4104	8699	2
4759	1125	6466	7495	1
6466	1125	8173	7510	2
10124	1506	13233	3350	3
10246	3883	13111	5743	3
10215	6261	13156	7998	3
8767	1110	11831	1506	4
8798	3502	13080	3883	4

AOI file C:\Users\chesne\Documents\Eye and Pen 2\data\tophe.AOI

Apply codes Close

Comment construction ventilateur :

On commence par la fabrication de la capsule moteur. A l'aide des raccords fournis sur la capsule de la capsule engrenage et moteur de la batterie. Et sur la plaque de la batterie mettre le module de commande. Raccorder les câbles de la batterie sur la capsule moteur et les câbles du module de commande sur la batterie.





Revenir la capsule engrenage et la fixer au ventilateur, ce bout




de cette capsule fixer la deuxième capsule moteur. A l'aide des raccords fournis sur la capsule de la capsule engrenage et moteur de la batterie. Et sur la plaque de la batterie mettre le module de commande. Raccorder les câbles de la batterie sur la capsule moteur et les câbles du module de commande sur la batterie.

Fin

X 15194 Y 5060 d(E) 6944,56 v(E) 17,85 d(T) 6396,76 v(T) 0,31 d(TE) 10649,92 d(nP) 0,00 C:\Users\chesne\Documents\Eye and Pen 2\data\tophe.AOI MSHS2.bmp [4276]

Semi-automated word separation

	
	Raccords
	Ventilateur
	Ob turateur

	Bus
	
	Caps engren

Comment construire un ventilateur.

On commence par le Raccords.

Prenons la capsule on insère les raccords dans les trous des flans.

N'oubliez pas de bien transpercer la capsule.

Ensuite on fixe le ventilateur à cette capsule.

Prenons la capsule engren et la fixe au ventilateur, au bout.

Raccords fixer sur la base de la capsule engren et moteur de la batterie. Et sur la base de la batterie mettre le module de commande. Mettre la cable de la batterie sur la capsule moteur et la cable du module de commande sur la batterie.

Fin

Word separation

Details

Word number 1 [Total: 110]

Tab number pressure code

Start 1 16 10

End 552 111 11

Text 1 Comment

Text 2

Text 3

☒ Code Tab data at word boundaries

☒ Code inter-word pauses

☒ Create sequences for words

☒ Create ADI for words

Ok Cancel

Protocol description

€p Description

Statistics Pauses and fixations Tab movements Eye movements Specifications

Production

Time before production (pause 0) 30707 Up pause threshold 50

Product duration 1186651 Down pause threshold 30

Last Up pause duration 116198 Fixation threshold 10

Details

	Stop events			Movements (samples)	
	Up pauses	Down pauses	Fixations	Tab	Eye
Number	751	1182	532	48654	517324
Total duration	656681	122805	60798	289516	1156560
Total distance	n/a	n/a	n/a	879,9054	270985,5349
Mean speed	n/a	n/a	n/a	3,0392	234,3030
Minimum	50	30	10	0,0000	0,0000
Maximum	38757	1482	12999	122,9300	13394,6900
Range	38707	1452	12989	122,9300	13394,6900
Q1	79,0000	50,0000	17,0000	1,7900	84,9700
Q2 (median)	105,0000	72,0000	27,0000	2,9100	157,6500
Q3	375,0000	112,0000	58,0000	4,8800	305,0000
Mean duration	874,4088	103,8959	114,2820	5,9505	2,2357
Standard deviation	2553,4725	101,2555	813,2642	7,6966	431,5494
Standard error	6,8966	4,6872	12,8467	0,0225	0,0772

In this example, a full text page is:
 ~ 520,000 eye-tracking data samples
 ~ 51,000 handwriting data samples

OK Save as...

Data extraction

(main categories)

Events

- ✓ All events
- ✓ Pauses during fixations and fixations during pauses
- ✓ Activated trigger zones on the tablet (Simple)

Pauses

- ✓ Pauses only
- ✓ Eye movements during pauses
- ✓ Fixations during pauses

Fixations

- ✓ Fixations only
- ✓ Eye movements in AOI
- ✓ Fixations in AOI

Tracing dynamics

Publications

Papers on method

- ✓ Alamargot, D., Chesnet, D., Dansac, C. & Ros, C. (2006). Eye and Pen: a new device to study reading during writing. *Behaviour Research Methods, Instruments and Computers*, **38**(2), 287-299.
- ✓ Chesnet, D., & Alamargot, D. (2005). Analyses en temps réel des activités oculaires et graphomotrices du scripteur: intérêt du dispositif 'Eye and Pen'. *L'Année Psychologique*, **105**(3), 477-520

Recent research papers

- ✓ Lambert, E., Alamargot, D., Laroque, D. & Caporossi, G. (in press). Dynamics of spelling process during a copy task. Effect of frequency and regularity. *Canadian Journal of Experimental Psychology*.
- ✓ Alamargot, D., Caporossi, G., Chesnet, D., & Ros, C. (2011). What Makes a Skilled Writer? Working Memory and Audience Awareness during Text Composition. *Learning and Individual Differences*.
- ✓ Alamargot, D., Plane, S., Lambert, E. & Chesnet, D. (2010). Using Eye and Pen Movements to Trace the Development of Writing Expertise: Case Studies of a Seventh, Ninth and Twelfth Grader, Graduate Student, and Professional Writer. *Reading and Writing*, **23**, 853-888.