e-EarlyCare-T

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Specialized and updated training on supporting advanced technologies for early childhood education and care professionals and graduates

MODULE VII.3

Early care and application of smart resources: use of eye tracking technology and the eEarlyCare web application

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I. Introduction

Module VII.3 refers to the use of intelligent resources for observation, analysis and intervention at early ages. Specifically, this part of Module VII will introduce the use of eye tracking technology applied to the assessment of children at an early age. In addition, it will present a web application, eEarlyCare, which allows observational analysis to be recorded and the results to be interpreted through a Learning Analytics system. This system offers personalised profiles for each user and, based on these profiles, provides proposals for individualised programmes for therapeutic intervention.

II. Objectives

2.1. To learn the functionalities of the use of eye tracking technology for the observation of skills in children at an early age.
2.2. To learn the possibilities offered by using the eEarlyCare web application for assessment and intervention in functional skills for the developmental period 0-6 years.

III. Content specific to the theme

3.1. Eye tracking applied to early intervention

First, we will address the concept of eye-tracking technology and its possible application in the evaluation of information processing during the resolution of a task with children (with and without impairments) at an early age.

3.1.1. What is eye-tracking technology?

Eye-tracking technology is based on eye tracking and measures eye movements. The explanation is basically the capture of eye tracking—while the user performs a task—through a pattern of infrared light directed towards the eyes. The infrared light is reflected by the eyes and the eye reflections are captured by the eye-tracker cameras. Then, from the application of algorithms, the eye tracker recognises where the user is looking. Figure 1, shows how it works, there is a stimulus on the computer screen, the eye perceives the image in a position of coordinate axes (these can be in 3D, x,y,z, or 2D x,y) in the position of the right eye and left eye. Also, eye movement can be recorded without the need for the subject to look at a screen, they can look at a blackboard, an object, or a surface, etc. (see Figure 2).

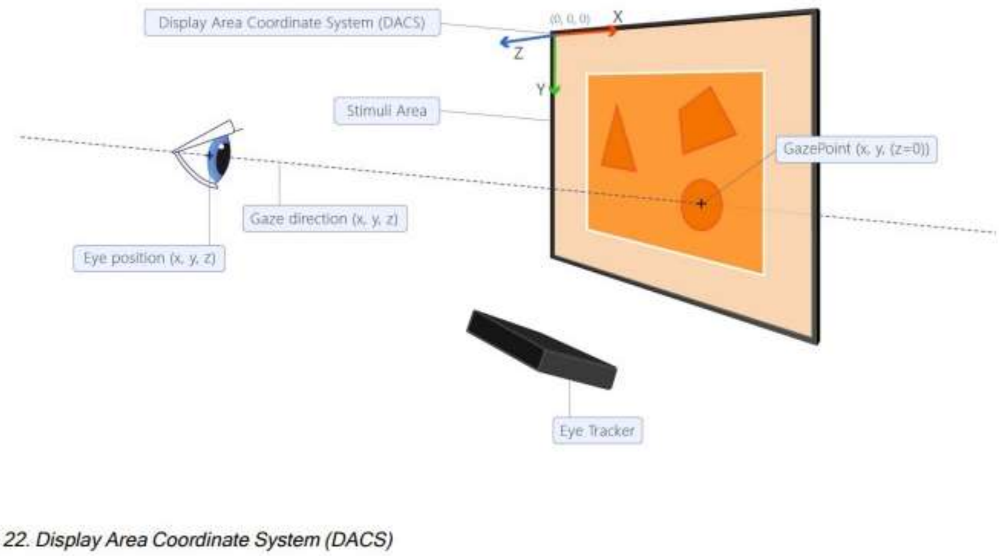


Figure 1. Taken from Tobii Pro Lab Manual v. 1.194 p. 155

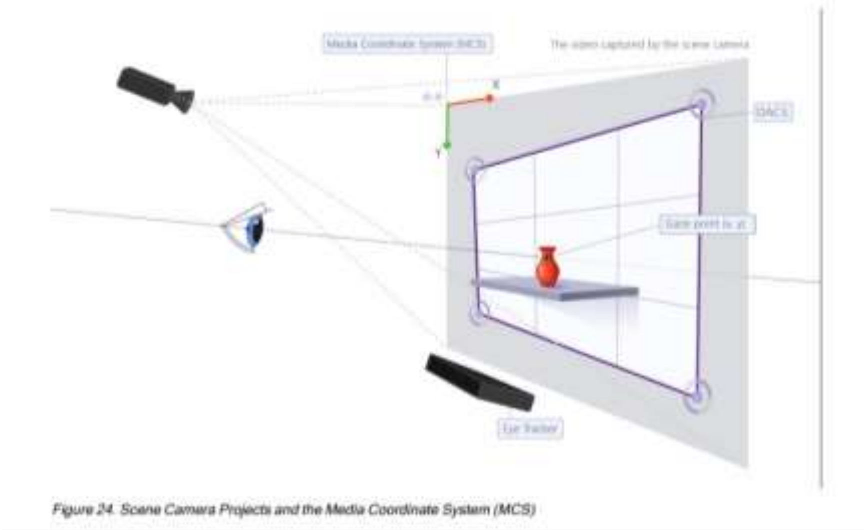


Figure 2. Taken from the Tobii Pro Lab Manual v. 1.194 p. 158

This is a useful option in observation and assessment of young children. An example of such an assessment is shown in Figure 3 and Figure 4 (in this case only the 2D coordinates, x, y coordinates, are analysed). These devices are very powerful and are highly capable of adjusting to head movements. They are therefore recommended for assessment of young children. They can capture eye movement data at speeds ranging from 60 Hz to 1200 Hz.

Figure 3. Image taken from Tobii information on the web link

Figure 4. Image taken from Tobii information on the web link

Another possibility is using glasses that incorporate eye-tracking software (see Figure 5). The glasses can measure using a 3D coordinate system. The eye position and gaze vectors are calculated from images of the eye on a 3D model. The gaze point is calculated as the vergence point between the two gaze vectors.

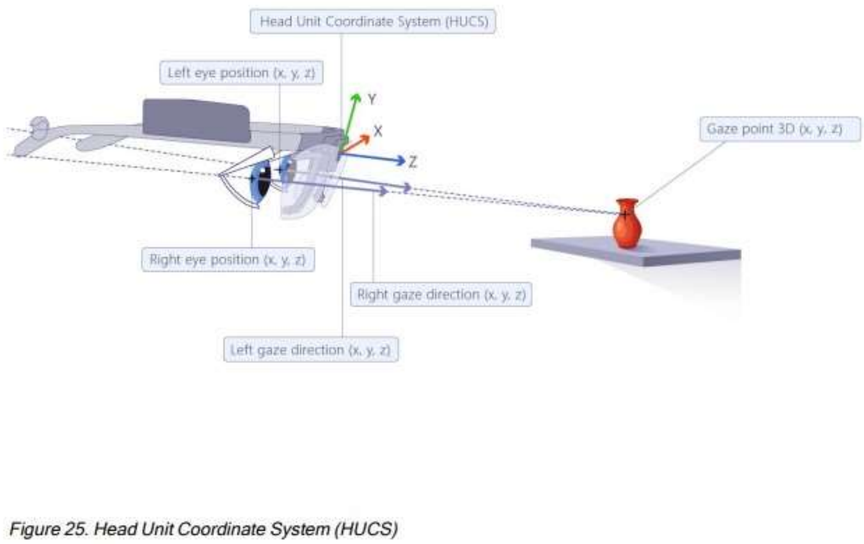


Figure 5. Taken from Tobii Pro Lab Manual v. 1.194 p. 159

In this process it is important to correctly calibrate gaze positioning. An example of a gaze adjustment positioning analysis is shown in Figure 6.

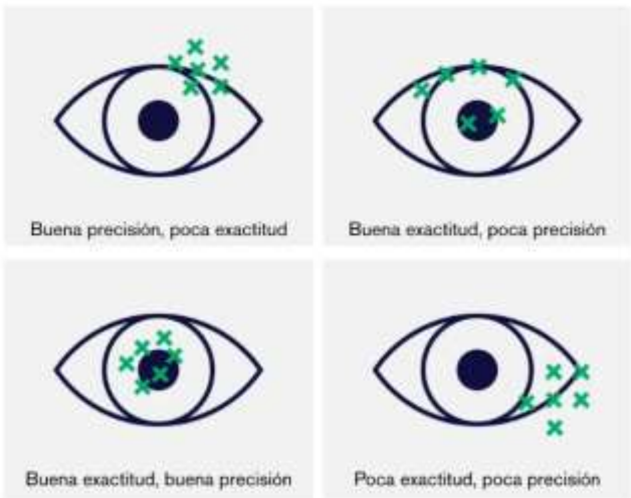


Figure 6. Taken from Tobii dynavox link

3.1.2. Registration metrics in eye tracking and their significance in information processing.

Eye tracking can record many metrics, which can be classified into static and dynamic metrics (Sáiz-Manzanares et al., 2020). The former are related to fixation, saccade and glance parameters. All have different extensions such as (frequency, speed, average duration, etc.). Dynamic metrics refer to the recording of the positional pattern of eye tracking performed, depending on the type of technology, they maybe called scan path or gaze point.

Table 1 shows the most significant metrics and their correspondence with the cognitive processes that occur during the performance of different tasks.

Table 1. Representative metrics in eye tracking and their correspondence with information processing. Adapted from Sáiz-Manzanares et al. (2019); Sáiz-Manzanares et al. (2020).

Metric	Acronym	Meaning	IP Correspondence
Duration of interval	DI	Duration of all intervals of cas Time of Interest, with means, medians, sums, frequencies, variances and standard deviations.	
Start of interval	YES	The starting time of all time intervals for each Time of Interest, with means, medians, sums, frequencies, variances and standard deviations.	
Number of Events	NE	Customised events and Live logged events, for each event time, with means, medians, sums, frequencies, variances and standard deviations.	
Validity of eye data	VED	Refers to whether the eyes have been correctly identified. That is, whether the calibration is correct.	
Calibration	C	Information on calibration adjustment.	
Fixation Count	FC	Number of fixations of all selected stimuli.	A high FC means a higher number of fixations on a stimulus, indicating that participants may possess less task knowledge or have difficulty discriminating between relevant and non-relevant information.
Fixation Duration	FD		Gives an indication of the user's level of interest and reaction times. Longer durations are usually associated with deeper cognitive processing and greater effort. The duration of the fixation also provides information on the search process.

Fixation Duration Average	FDA	Average duration of fixation	A longer FDA means that the participant spends more time analysing and interpreting the information content within the different AOIs.
Fixation Duration Maximum	FDMa	Maximum duration of fixation	Refers to reaction times.
Fixation Duration Minimum	FDMi	Minimum duration of fixation	Refers to reaction times.
Fixation Dispersion Total	FDT	Sums all dispersions on the fixation axes (x,y or x,y,z) depending on whether the device measures in 2D or 3D.	Refers to the perception of the information in different components of the task.
Fixation Dispersion Average	FDA	Sum of all fixation dispersions on the axes divided by the number of fixations in the test.	analyses the dispersions in each of the fixations on thedifferent stimuli
Saccade Count	SC	Total number of saccades in each of the stimuli.	More saccades mean more search strategies. The greater the amplitude of the saccade, the lower the effort. cognitive effort. It may also refer to problems in understanding information.
Saccade Frequency Count	SFC	Sum of the frequency of all saccades	Refers to the frequency of use of saccades which are related to search strategies.
Saccade Duration Total	SDT	Sum of the duration of all saccades	Refers to the frequency of use of saccades which are related to search strategies.
Saccade Duration Average	SDA	Average duration of saccades in each AOI	This data allows the discrimination of dependent or independent field users.
Saccade Duration Maximum	SDMa	Maximum duration of the saccade	Novice users in the execution of a task have shorter saccades.
Saccade Duration Minimum	SDMi	Minimum duration of the saccade	Novice users in the execution of a task have shorter saccades.
Saccade Amplitude Total	SAT	Sum of the amplitude of all saccades	Novice users in the execution of a task have shorter saccades.

Saccade Amplitude Maximum	SAMa		Novice users in the execution of a task have shorter saccades.
Saccade Amplitude Minimum	SAMi		Novice users in the execution of a task have shorter saccades.
Saccade Velocity Total	SVT	Sum of the speed of each saccade	This is directly related to the speed of information processing. when moving from one element to another within a stimulus.
Saccade Velocity Maximum	SVMa	Maximum value of the recorded speed of the saccade	This is directly related to the speed of information processing. when moving from one element to another within a stimulus.
Saccade Velocity Minimum	SVMi	Minimum value of the recorded speed of the saccade	This is directly related to the speed of information processing. when moving from one element to another within a stimulus.
Saccade Latency Average	SLA	Equal to the time between the end of one saccade and the start of the next saccade.	This is directly related to reaction times in information processing. The initial latency of the saccade provides time-related information on the search process.
Blink Count	BC	Number of flashes during activity	Blinking is related to information processing during exposure. to a stimulus to generate the next action. Users with faster information processing may have shorter blinks. However, this action can also occur where attention is required. These results must be compared with results from other metrics to fit them within the analysis of a learning pattern.
Blink Frequency Count	BFC	Number of flashes of all selected tests trials per second divided by number of selected trials	
Blink Duration Total	BDT	Sum of the duration of all the flickering of selected trials divided by the number of tests selected	
Blink Duration Average	BDA	The sum of the duration of all the flashing of all selected tests divided by the number of selected tests	
Blink Duration Maximum	BDMa		

Blink Duration Minimum	BDMi		
Pupil diameter	PS	Pupil diameter	Refers to the interest that a stimulus or part of it can attract the user's attention.
Total duration of Visit	TDV	Total time each participant has visited the AOI house.	Gives data on attention to a stimulus or part of a stimulus.
Average duration of Visit	ADV	Average duration of each participant for each AOI over the total average.	
Number of Visits	NV	Number of visits within each AOI.	
Scan Path Length	SPL	Provides the learning pattern user's behavioural behaviour during task resolution	The study of behavioural patterns of learning will facilitate guidance on how to learn. The length of the scan path provides information on reaction times in tasks without predetermined duration.
Dwell Time	DWT	Duration of all fixations and saccades within an AOI, including revisits (exits and re-entries) of all participants in the study divided by the number of participants.	DWT refers to a participant's interest in a stimulus within a given AOI.
Glance Duration	GD	Duration of the saccade when entering the AOI plus the sum of all fixation and saccade durations before leaving the AOI.	GD indicates reaction times when processing information within a stimulus and an AOI. It helps to distinguish between field dependent vs. field independent participants.
Fun Duration	DD	The sum of all durations of saccades into and out of the AOI plus the sum of all durations of fixations and saccades within the AOI before exiting.	DD can be used to analyse the input, dwell time and output time of each stimulus inserted into each AOI.
Glance Count	GC	Number of glances at a target (taken from the outside) in a given period with both eyes.	GC helps to analyse reaction times and their duration for different stimuli. This provides information about how information is processed in different participants.

3.1.3. Synchronisation of eye tracking with other records

a) Psychogalvanic Skin Response Recording (GSR)

Nowadays, eye tracking technology allows synchronisation of information from eye tracking with other recording channels such as the Psychogalvanic Skin Response (GSR). The traditional theory of galvanic skin response analysis is based on the assumption that skin resistance varies with the state of the sweat glands. Sweating in the human body is regulated by the Autonomic Nervous System (ANS). In particular, if the sympathetic branch (SNS) of the ANS is highly aroused, sweat gland activity also increases, which in turn increases skin conductance, and vice versa. Thus, skin conductance can be a measure of human SNS responses. This system is directly involved in the regulation of emotional behaviour. Other studies have highlighted the relationship between the GSR signal and some physical states that can influence mental states, such as stress, fatigue and activity engagement. The GSR signal is recorded with two electrodes placed on the second and third fingers of one hand. The variation of an applied low voltage current between the two electrodes is used as a measure of the electrodermal activity (EDA).

GSR can offer the following measures:

Activation: This refers to the baseline level of physiological arousal produced by a stimulus or situation. Emotional arousal may be due to a positive or negative emotional response. Activation is expressed in percentages from a defined baseline during calibration stimuli. Values below 0 are associated with a relaxed or calm state. Values above 0 are associated with a state of arousal. A value of -100% refers to the maximum relaxation response observed during calibration. A value of 100% refers to the maximum observed response to the calibration media. A value greater than 100% is possible if the calculated response exceeds that measured during calibration.

Impact: Emotional impact measures the number and intensity of one-off changes in emotional state produced by a stimulus, external event or during task performance. In other words, impact identifies something that is striking or produces arousal or stress. Impact is expressed as a percentage. A value of 0% means that there is no impact. A value of 100% equals the value measured in response to the calibration means. A value higher than 100% is possible if the calculated reaction exceeds that measured during calibration.

b) Encephalographic recording (EEG).

Depending on the device, EEG recordings can record information from 8, 16, 32 and 64 channels via dry or semi-dry electrodes. These sensors are designed for versatile monitoring with respect to a wide variety of monitoring environments from a high level of accuracy even in motion. An example of the recording areas can be seen in Figure 7, taken from free Bitbrain data. Specifically, 16 channels in developmental, frontal, prefrontal and occipital areas are analysed in this image.

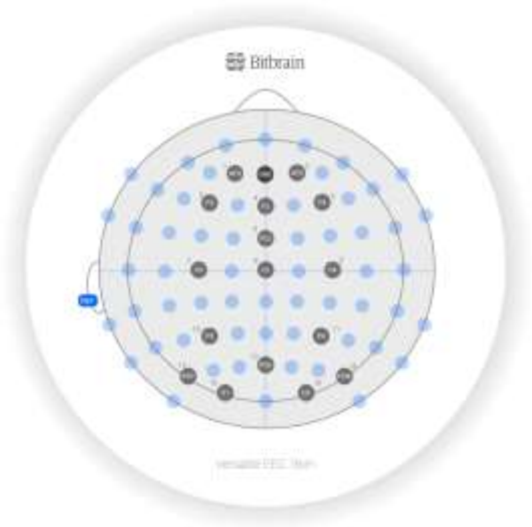


Figure 7. 16-channel EEG recording image taken from Bitbrain link.

The metrics that can be extracted from EEG are:

Valence: measures the degree of attraction experienced in response to stimuli or a situation, ranging from a positive/pleasant reaction to a negative/unpleasant reaction. Valence is expressed as a percentage. A value of 100% positive or negative is equivalent to the value measured in response to the calibration medium. A valence level higher than 100% (positive or negative) is possible if the calculated reaction exceeds that measured during calibration.

Memorisation: refers to workload, measuring the neurological focus or concentration of a participant when presented with stimuli. In other words, it represents the use of cognitive resources to perform a task or visualise a stimulus. Workload is expressed as a percentage. Values close to 0% indicate that the participant is very distracted, while a value close to 100% indicates that the participant is very attentive to the stimulus.

Engagement: refers to the degree of involvement or connection between the participant and the stimulus or task. It is a more complex indicator than attention, as a participant may be attentive to a task even if they do not find the information presented interesting. Involvement is expressed as a percentage. A value close to 0% indicates no connection or link to the stimuli. A value close to 100% indicates high engagement with the stimuli or task.

All metrics can be incorporated and analysed in different logging channels, an example can be found in Figure 8.

Figure 8. Multi-channel log analysis Taken from Bitbrain web

Application of this technology can be found in studies by Dollion et al. (2021); Boxhoorn et al. (2019); Murias et al. (2017) and Leckey et al. (2020).

3.1.4. Biometric markers applied to assessment and intervention with young children.

The results of recent studies on the use of biometric measures applied to the analysis of information processing are promising. Biometric measures allow people's unconscious and involuntary behaviours to be captured (Borgianni and Maccioni, 2020). The use of biometric measures is useful for understanding the ways in which humans process information and emotional responses. Also, different studies are being carried out to test the effectiveness of the application of different Machine Learning techniques with respect to the accuracy in the analysis of the results of different biometric records (Borgianni and Maccioni, 2020). Specifically, regression machine learning techniques have been found to be more effective than using Naive Bayes algorithms and the J48 and Random Forest decision tree algorithms (see Module IV. 1).

The following is a list of recent research in which eye-tracking technology has been applied in studies with infants and children using different single and multi-channel eye tracking equipment, see Table 2.

Table 2. List of recent research using eye-tracking technology to analyse different aspects of information processing in infants and young children with and without impairments.

Study	Summary	Functionality of the application of eye tracking technology	Applied tool
Gastmann, F., and Poarch, G.J. (2022). Cross-language activation during word recognition in child second-language learners and the role of executive function. *Journal of Experimental Child Psychology*, *221*, 105443. https://doi.org/10.1016/j.jecp.2022.105443	This study investigated lexical retrieval processes in bilingual children aged 4-6 years, exploring cross-linguistic activation during second language (L2) word recognition in semantically related and unrelated contexts in English. Both button press (reaction times and accuracies) and eye tracking data (percentage of glances to the target) and eye tracking (percentage of glances to the target) showed a significant facilitation effect of cognates, indicating that children's performance was enhanced by cognate words. However, the degree of phonological overlap of cognates did not modulate their performance. In addition, a semantic interference effect was observed in the children's eye movement data. However, in these young L2 learners, cognate status exerted a comparatively stronger impact on L2 word recognition than semantic relatedness. Finally, correlation analyses between the children's non-cognitive performance and executive function yielded a significant positive correlation between non-cognitive performance and their inhibitory control, suggesting that non-cognitive processing was more dependent on inhibitory control than cognitive processing.	Analysis of information retrieval processes in bilingual children aged 4 to 6 years. Analysis of inhibitory control.	SMI Experiment Center and run on a laptop (HP ZBook 15 G2) with a 15.6-inch display
Gepner, B., Charrier, A., Arciszewski, T., & Tardif, C. (2022). Slowness Therapy for Children with Autism Spectrum Disorder: A Blind Longitudinal Randomized Controlled Study. *Journal of Autism and Developmental Disorders. 52*, 3102-3115. https://doi.org/10.1007/s10803-021-05183-6	The world often moves too fast for children with autism spectrum disorder (ASD) to process. This study tested the therapeutic efficacy of slowing down input in children with ASD. Over 12 months, 12 children with ASD had weekly speech therapy sessions in which stimuli were played slowly on a PC, while 11 children with ASD of the same age and level received speech therapy using real-time stimuli. At the beginning and end of the study, all participants	Children diagnosed with ASD according to DSM-5 criteria between the ages of 3 and 8 years.	Tobii T120 Eye Tracker® (eye tracker) (Tobii, Stockholm, Sweden). This system made it possible to capture time-resolved data (120 Hz sampling rate)

	were assessed on communication, imitation, facial emotion recognition, behaviour and face exploration. While communication and facial emotion recognition improved in both groups, imitation increased, inappropriate behaviours decreased and mouth and eye fixation time increased only in the group using slowness. Slow therapy seems very promising for children with ASD.		spatial resolution (accuracy of .,4°) at a distance of approximately 50cm from the screen, which corresponds to a visual angle of 30°. Since this eye-tracking system is non-invasive, tolerates some head movement and looks like a TV or PC screen, it is very suitable for children aged 3 to 8 years. Video streams with a resolution of 1024 × 764 pixels were presented with Tobii Pro Studio™ version 3.4.0 software on a 17-inch LCD screen on a 17-inch LCD screen (Tobii T120 screen, 8-bit colour, 1280 × 1024 resolution, 75 Hz refresh rate). Two speakers. Two loudspeakers were also connected to the PC to amplify the sound from the video sequences (HP 2.0 multimedia loudspeaker, 1 W mean square, signal-to-noise ratio = 70 dB). Studio 2.2®, a gaze analysis software, was used on the PC to process the data and identify fixations using the ClearView fixation filter.

King, J., and Markant, J.(2022). Selective attention to lesson-relevant contextual information promotes 3- to 5-year-old children's learning. *Developmental Science, 2022,* 25, e13237. https://doi.org/10.1111/desc.13237	Attention to distracting or competing information is often considered detrimental to learning, but the presence of competing information can also facilitate learning when it is relevant to the goals of the task at hand. Educational environments often contain contextual elements, such as classroom décor or visual aids, to enhance students' learning. Despite this, most research examining the effects of contextual information on children's learning has only used lesson-irrelevant stimuli. Although this research has shown that increased attention to task-irrelevant information hinders learning, the extent to which looking at lesson-relevant information may benefit children's learning is unknown. We addressed this question by examining 3- to 5-year-olds' attention to and learning of lesson-relevant contextual information. Children's eye movements were recorded as they watched science video lessons, while lesson-relevant and lesson-irrelevant images appeared in the periphery. Learning was assessed as a function of improvements in the video lessons and selective attention skills were measured separately using the Track-It task. Overall, children spent more time looking at the lesson versus irrelevant images, and those with greater initial knowledge of the lesson topics or with more advanced selective attention skills showed a greater preference for relevant images. This was related to more effective learning during trials in which both relevant and irrelevant images were present. These results suggest that the effects of contextual information on early learning depend on the relationship between information content and task goals, as well as on children's ability to actively select task-relevant information from their environment.	Selective attention to relevant vs. non-relevant information. Work was carried out with children aged 3 to 5 years.	Eyelink 1000 remote eye tracker (SR Research Ltd., Toronto, ON, Canada).
Kong, X-J., Wei, Z., Sun, B., Tu, Y., Huang, Y., Cheng, M., Yu, S., Wilson, G., Park, J., Feng, Z., Vangel, M., Kong, J	Children with autism spectrum disorder (ASD) have been observed to have gaze fixation difficulties, although the dynamics of fixation patterns with age are unclear. In this	Children with (diagnosed according to DSM-5 criteria) and without autism spectrum	The SMI RED250 portable eye-tracking system was

and Wan, G (2022) Different Eye Tracking Patterns in Autism Spectrum Disorder in Toddler and Preschool Children. *Front. Psychiatry 13*, 899521. https://doi.org/10.1111/desc.13237	study, fixation patterns among toddlers and preschoolers with and without ASD were investigated while viewing video clips and still images. (i.e., face with mouth movement, biological movement, face with movement vs. moving object, still face image vs. objects, and moving toys). Significant differences were found in the percentage of fixation time of children with ASD vs. children without ASD in almost all areas of interest (AOI), except for the moving toy (helicopter). A diagnostic group (ASD vs. TD) and chronological age (toddlers vs. preschoolers) were also observed for the AOI of the eyes. during the mouth movement video clip. Support vector machine analysis showed that the classifier could discriminate ASD from TD in toddlers with 80% accuracy and could discriminate ASD from TD in preschoolers with 71% accuracy. The results suggest that toddlers and preschoolers may be associated with common and distinct fixation patterns. A combination of eye-tracking and eye-tracking and machine learning has the potential to shed light on the development of new methods for early detection/diagnosis of ASD.	disorder, age ranges 1.5-3 years and 3-5 years. Analysis of fixation patterns on static and moving stimuli.	used in data collection. Screen resolution was set to 1,024 768 pixels with a sampling frequency of 250 Hz and spatial resolution of 0.03 degrees
Mulder, H., Oudgenoeg-Paz, O., Verhagen, J., van der Ham, I.J.M., and Van der Stigcheld, S. (2022). Infant walking experience is related to the development of selective attention. *Journal of Experimental Child Psychology, 220*, 105425. https://doi.org/10.1016/j.jecp.2022.105425	Previous studies have shown that the way babies perceive and explore the world changes when they move from crawling to walking. The onset of walking in infants often precedes advances in cognitive development, such as accelerated language growth. However, the underlying mechanism that explains this association between the experience of walking and cognition is largely unknown. Selective attention is a key driver of learning in multiple domains. We propose that the alteration of visual information obtained by children in the transition to walking is related to the development of selective attention. and that gains in selective attention may explain previously reported gains in other cognitive domains. As a first step in testing this hypothesis,	Analysis of selective attention	Tobii T60 binocular eye tracker with a 17-inch LCD monitor (accuracy = 0.5º, sampling rate = 60 Hz).

	we investigated how the experience of walking relates to selective attention. In Study 1, 14-month-old crawlers, novice walkers and experts performed on a visual search eye-tracking task (N = 47), including feature and conjunction (effort) items. Walkers outperformed crawlers on the task overall, and effortful search in expert walkers compared to novice walkers, after controlling for crawling onset and general developmental differences occurring prior to gait onset. In Study 2, earlier onset of walking was associated with better visual search performance in 2-year-olds (N = 913). The association appeared to be due to the difference between the 10% of later walkers and early/mid walkers.		
Ståhlberg-Forsén, E., Latvab, R., Leppänen, J., Lehtonen, L., & Stolta, S. (2022). Eye tracking based assessment of lexical processing and early lexical development in very preterm children. *Early Human Development 170,* 10. https://doi.org/10.1016/j.earlhumdev.2022.105603	The associations between lexical processing and lexical development during the second year of life have been have been little studied in preterm children. The aims of this study were to assess the associations between lexical processing at 18 months and lexical development between 12 and 18 months in very preterm children. A correlational study was applied. We worked with 25 Finnish children born at less than 32 weeks gestation. The measures found were lexical processing (reaction time RT; correct gaze time CLT) was measured with an eye-tracking technology-based task at 18 months corrected age. Lexical development was measured longitudinally at 12, 15 and 18 months corrected age using the following assessment instruments: the short version of the MacArthur Communicative Development Inventories and the Communication and Symbolic Behavior Scale: Infant and Toddler Checklist. Results: The higher the child's TR, the weaker the child's expressive skills at 12 and 15 months (correlation coefficients from 0.45 to 0.51). The more the child looked at the target image compared to the distractor (CLT), the stronger the child's expressive skills were at 18 months (r = 0.45-0.52). A linear regression model with RT and gender as in-	Reaction times and correct eye gaze time in lexical processing tasks	The Tobii X2-60 Infrared Eye Tracker which uses image sensors and processing algorithms to track the point of the participant's gaze on a screen

	dependent variables explained 33% of the variance in lexical skills at 18 months. A model with CLT explained 40% of expressive skills at 18 months. The conclusions were that lexical processing at 18 months was associated with expressive lexical development in very preterm children. The results suggest that methods based on eye-tracking technology may be useful for the assessment of early lexical growth in preterm children, although further research is needed to evaluate the psychometric properties and predictive value of the method.		
Tan, S.H.J., Kalashnikova, M., Di Liberto, M., Crosse, M.J., and Burnham, D.(2022). Seeing a talking face matters: The relationship between cortical tracking of continuous auditory-visual speech and gaze behaviour in infants, children and adults. *NeuroImage, 256,* 119217. https://doi.org/10.1016/j.neuroimage.2022.119217	The auditory-visual speech benefit, i.e. the benefit that visual speech signals bring to auditory speech perception, is experienced from infancy and continues to be experienced to a greater degree with age. Although both behavioural and neurophysiological evidence exists for children and adults, only behavioural evidence exists for infants, as no neurophysiological study has provided a comprehensive examination of the benefit of auditory-visual speech in infants. It is also surprising that most studies on the benefit of auditory-visual speech do not simultaneously report on gaze behaviour, especially since the benefit of auditory-visual speech is based on the assumption that listeners attend to the speaker's face and that there are significant individual differences in gaze behaviour. To address these gaps, we simultaneously recorded electroencephalographic (EEG) and eye-tracking data from 5-month-olds, 4-year-olds and adults while they were presented with a speaker in auditory-only (AO), visual-only (VO) and auditory-visual (AV) modes. Cortical tracking analyses involving direct encoding models of the speech envelope revealed that there was a benefit of auditory-visual speech [i.e., AV > (A + V)], evident in 5-month-olds and adults, but not in 4-year-olds. Examination of cortical tracking accuracy in relation to gaze behaviour showed that infants' relative attention to the	Auditory-visual speech analysis. Multi-channel study of visual tracking and EEG recordings on attentional analysis of these bimodal (visual and auditory) stimuli in five-month-old monolingual Australian children. Monolingual Australian children aged four years. Monolingual adults aged 18-56 years.	EEG over 92 channels ELAN software (version 5.9)

	speaker's mouth (in front of the eyes) was positively correlated with cortical tracking accuracy of VO speech, whereas adults' attention to the screen in general was negatively correlated with cortical tracking accuracy of VO speech. This study provides the first neurophysiological evidence for the benefit of auditory-visual speech in infants and our results suggest ways in which current models of speech processing can be adjusted.		

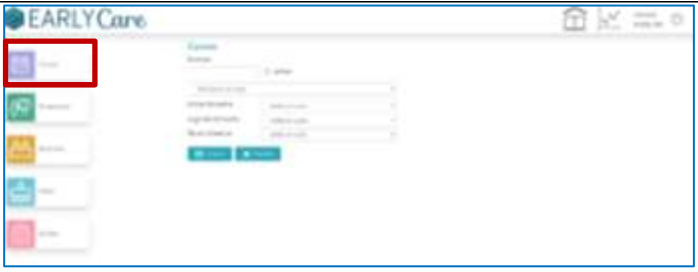
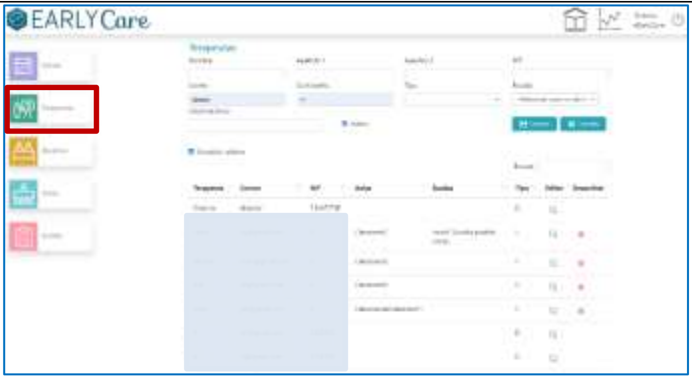
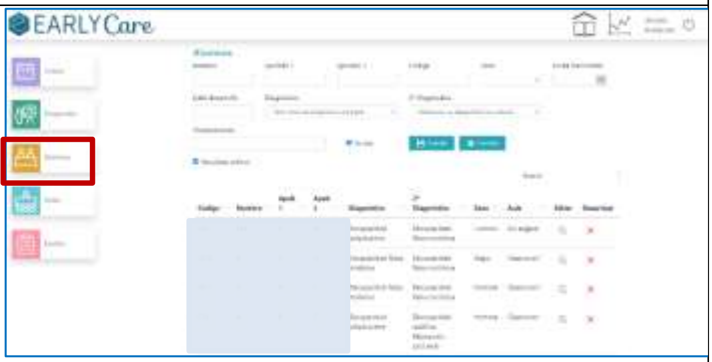
3.2. eEarlyCare web application

eEarlyCare is a web application that has been developed over several proof-of-concept phases financed with FEDER funds through the Junta de Castilla y León and the University of Burgos (Spain) (Sáiz-Manzanares, Marticorena-Sánchez and Arnaiz-González, and Díez-Pastor, 2020a; Sáiz-Manzanares, Marticorena-Sánchez and Arnaiz-González, 2020b). e-EarlyCare, incorporates an assessment scale of functional skills for ages 0-6 years in 11 functional areas (Autonomy in feeding, Personal care and hygiene, Dressing and undressing autonomy, Sphincter control, Functional mobility, Communication and language, Task resolution in social contexts, Interactive and symbolic play, Daily life routines, Adaptive behaviour, and Attention). The application allows assessments to be recorded and the data to be interpreted through an integrated Learning Analytics system. This system analyses the results from a comparison with the chronological ages assigned to each assessed behaviour (using a scale of developmental ages accepted by the scientific community, based on developmental scales and inventories such as the Brunet Lézine Scale, the Batelle Development Inventory, the Portage Guide, the PDI scale, etc.). In other words, it offers a comparison profile between the expected score at the chronological age and the actual score. The professional can also choose the number of standard deviations to apply with respect to the mean assigned to each assessed behaviour. Then, depending on the results from the assessment phase, the web application offers a possible therapeutic intervention programme. The programme detects the area or areas of functional development and the most affected behaviours (i.e., where there are the largest gaps compared to the chronological reference age). In addition, for each area, functional sub-area and behaviour, activities are proposed to initiate the therapeutic intervention programme. The application allows three evaluations per year (initial evaluation or baseline, intermediate evaluation or follow-up 1 and final evaluation or follow-up 2). The application also offers developmental analysis profiles that can be individual and/or grouped for each assessment. Similarly, the tool allows for longitudinal analysis of the three evaluations.

The eEarlyCare web application can be used in two roles, (educational or therapeutic) centre director or manager, and educator or therapist.

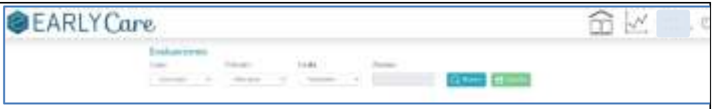
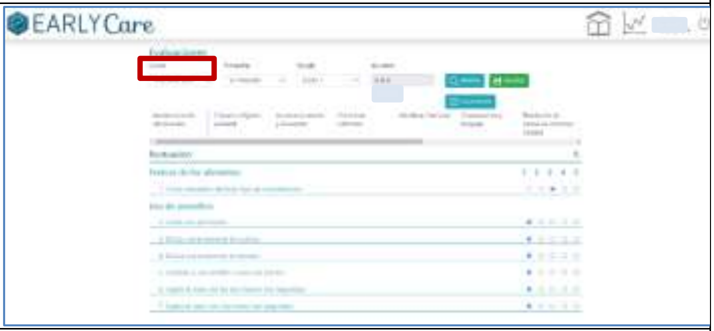
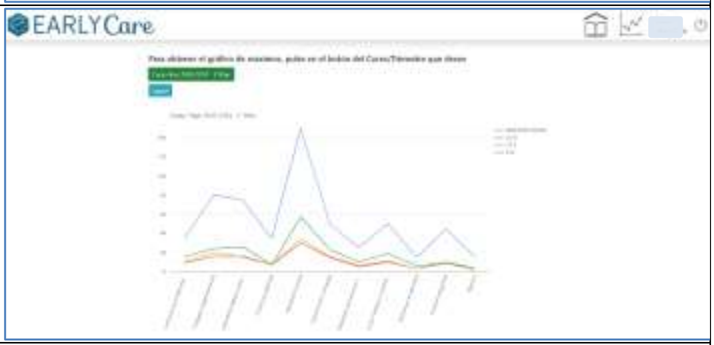
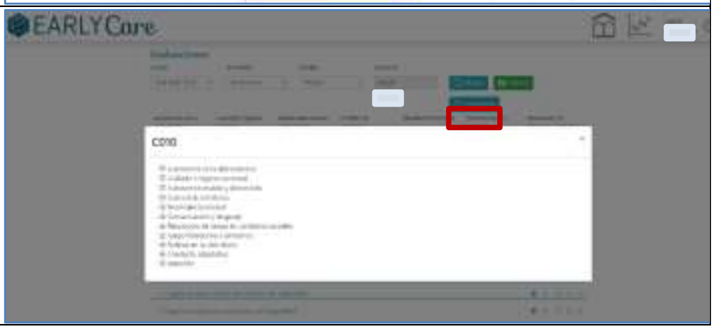
An example of how the tool works for a centre director or manager is given in Figure 9 and an example of how it works for a therapist is shown in Figure 10.

Figure 9. Functioning of the eEarlyCare web application for a centre manager.

	
Assignment of therapists	
Assignment of users	
Classroom allocation	
Using the Learning Analytics module	

Obtaining an individual development profile. * The application allows the graph to be exported. ** The blue line indicates the expected development and the line graph indicates the development of the selected user.	
Obtaining a group development profile. * The application allows the graph to be exported. ** The blue line indicates expected development and the other lines indicate the development of each user assigned to an intervention classroom.	
Individual developmental outcome for each behaviour. * The application allows the graph to be exported.	
Obtaining comparative group development in each behaviour.	

Figure 10. Operation of the eEarlyCare web application for a therapist.

	
Conducting assessments on assigned users	
Obtaining a development profile by individual or group functional areas or sub-areas. * The application allows the graph to be exported. ** The blue line indicates expected development and the other lines indicate the development of each user assigned to that intervention classroom.	
Obtaining an individual or group developmental profile for the behaviours assessed in each functional area or sub-area. * The application allows the graph to be exported.	
Depending on the developmental profile, a personalised intervention programme can be produced for the areas, sub-areas and behaviours in with the largest gaps between expected and actual development.	

Each functional area is assigned a colour. *The guidelines for intervention are graded in order of difficulty according to the results of the assessment.	
	
	
	
	

The application also allows the results of the evaluations to be exported as an Excel spreadsheet so that supervised and unsupervised automatic learning techniques can later be implemented (an example of how this works is shown in Figure 11). The former techniques will provide information on prediction and the latter on clustering. Both are highly functional for working with people with developmental disabilities. For example, predicting the priority behaviour(s) for therapeutic intervention is key in producing an accurate therapeutic intervention. Likewise, grouping users with similar impairments in some of the areas of development can give those responsible for the intervention centre key data for programming therapeutic intervention sessions with different professionals (occupational therapist, physiotherapist, speech therapist, etc.). This will help to better distribute the centre's resources and improve the quality of the service. Therefore, implementing this technology will foreseeably reduce intervention costs, since on the one hand it will offer an analysis of the patient's or user's development through the application of data interpretation and visualisation techniques, and on the other it will guide the professionals' intervention towards the development of precision treatment. The eEarlyCare web application is available in Spanish and English.

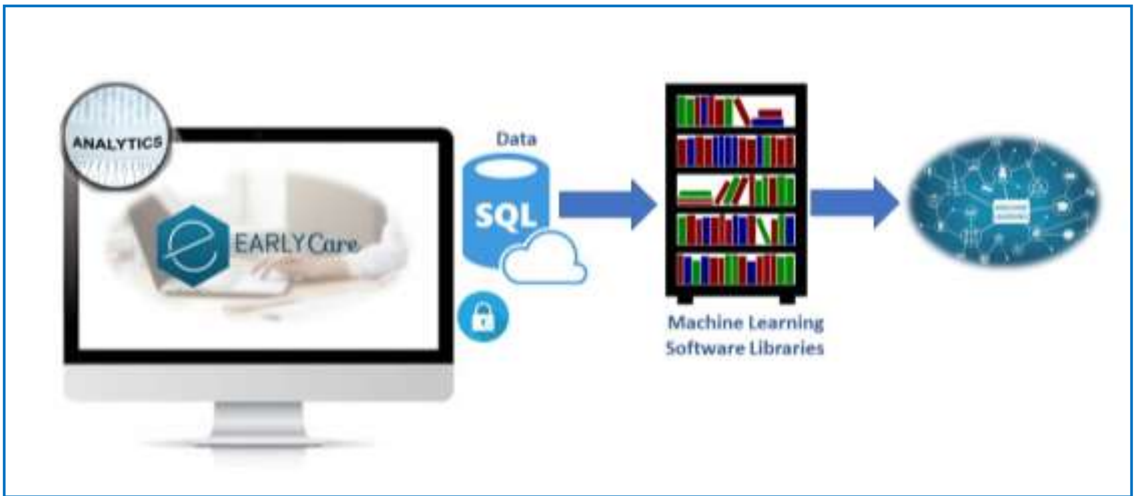


Figure 11. Operation of the e-EarlyCare web application system using Machine Learning techniques.

3.2.1. eEarlyCare web application functionality: representative studies.

The eEarlyCare application has been used with children who have a variety of developmental disabilities, the most representative studies can be found in Sáiz-Manzanares et al. (2020a; 2020b; 2022).

Summary

In this part of Module VII, Module VII. 3, we have looked at using eye-tracking technology for the evaluation of different cognitive strategies during information processing in children at an early age. We also examined the use of different Machine

Learning techniques to interpret the records provided by eye tracking. In addition, the eEarycare web application was presented, which allows results related to evaluating functional skills in 11 areas of development to be recorded and interpreted through a Learning Analytics system. This web application provides a development profile and also proposes personalised intervention in the development areas where the greatest impairment has been detected.

Glossary

ANS: Autonomous Nervous System

SNS: Sympathetic Nervous System

EDA: Electrodermal activity

EEG: Electroencephalogram

All other acronyms and meanings can be found in Table 1.

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Resources

Web

Assessment with young children with eye tracking	Link
Use of eye tracking for people with special educational needs	Link
Tobii dynavox english	Link
Tobii dynavox English	Link
Tobii neonatal and infant research	Link
Research in Developmental Psychology	Link
Autism Spectrum Research	Link