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Community on Food Consumer Science

D6.2 Software prototypes for integration and analysis of multi-modal psychophysiological data

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Executive Summary

COMFOCUS work package 6 focuses on emerging technologies and their implementation and relevance to the field of food consumers. Different from the more established self-report measures (reported in WP4), the emerging technologies have a weaker history of use within the food consumer science domain.

The emerging technologies reported in COMFOCUS deliverable D6.1. are the key candidates (together with EEG and virtual/augmented reality) for application in COMFOCUS forthcoming Open Call 2. Those measures have various differentiating features, including that (i) they are time series (repeated measures over time of heart beats etc.), (ii) there reflect bodily reactions in response to a stimulus field (which needs to be recorded in parallel and time stamped with the bodily response to be relevant), and (iii) the bodily responses are very sensitive to unexpected events during the data collection (distraction, movements etc.) challenging the quality and quality control of the data.

COMFOCUS task 6.2 has developed prototype software which will integrate and synchronize psychophysiological data acquired using the protocols developed in Task 6.1. In order to optimize the possibilities for multimodal data analysis, it is necessary that data streams in an experiment are integrated and aligned with respect to time. The software is based on current software from the partner Noldus, considerably improved with respect to performance (to process big data), security (GDPR compliance) and analysis. Ideally, panel data and self-report measures will also be integrated at later stage. Sensor integration has been developed in an open way, to maximise the number of IoT and other sensors (eye trackers, physiology acquisition, wearables, etc) which can be used with the system. The prototype software for technical harmonisation of psychophysiological data acquisition will be used in Open Call 2, where appropriate.

NoldusHub Prototype demonstration

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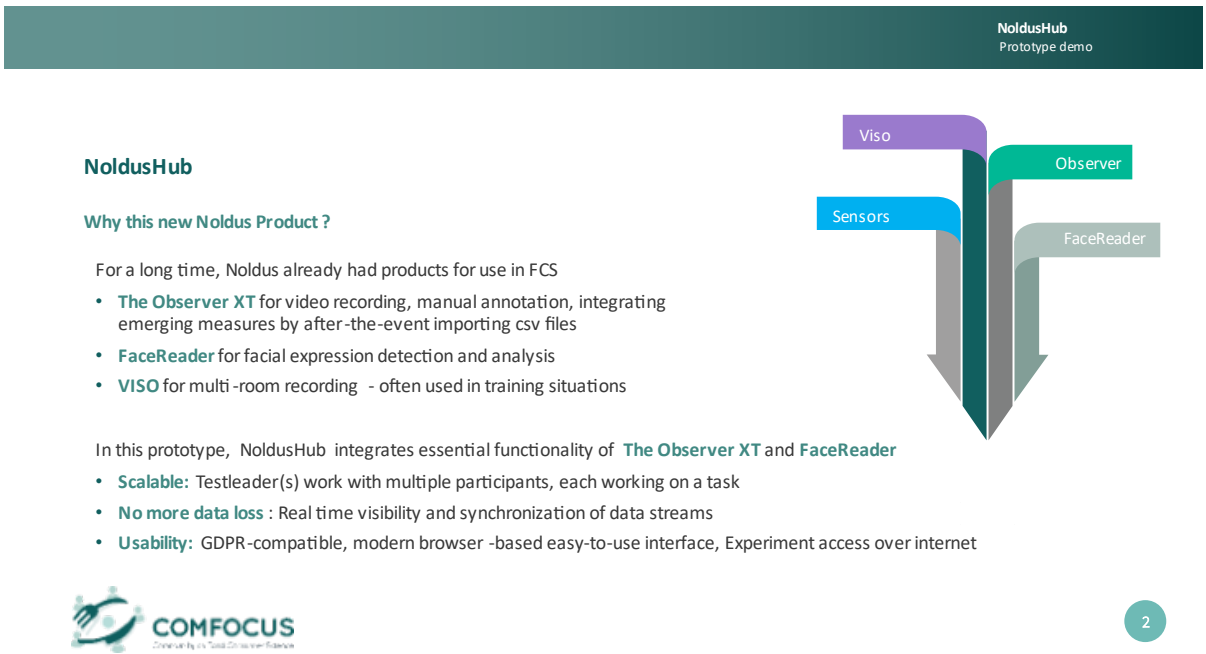
Task 6.2 aims to create prototype software which will integrate and synchronize psychophysiological data acquired using the protocols developed in Task 6.1. In order to optimize the possibilities for multimodal data analysis, it is necessary that data streams in an experiment are integrated and aligned with respect to time. The software will be based on current software from the partner Noldus, considerably improved with respect to performance (to process big data), security (GDPR compliance) and analysis. Ideally, panel data and self-report measures will also be integrated. Sensor integration will be developed in an open way, to maximise the number of IoT and other sensors (eye trackers, physiology acquisition, wearables, etc) which can be used with the system. Sub-projects will be selected provide datasets labelled with relevant high-level mental constructs such as confusion, stress, pleasure, and these datasets will be used to train AI/machine learning based analysis modules.



The Observer XT already allows integration of externally recorded data, provided that that data is exported by its recording device into a csv file. This implies that the data is collected after the sessions has stopped.

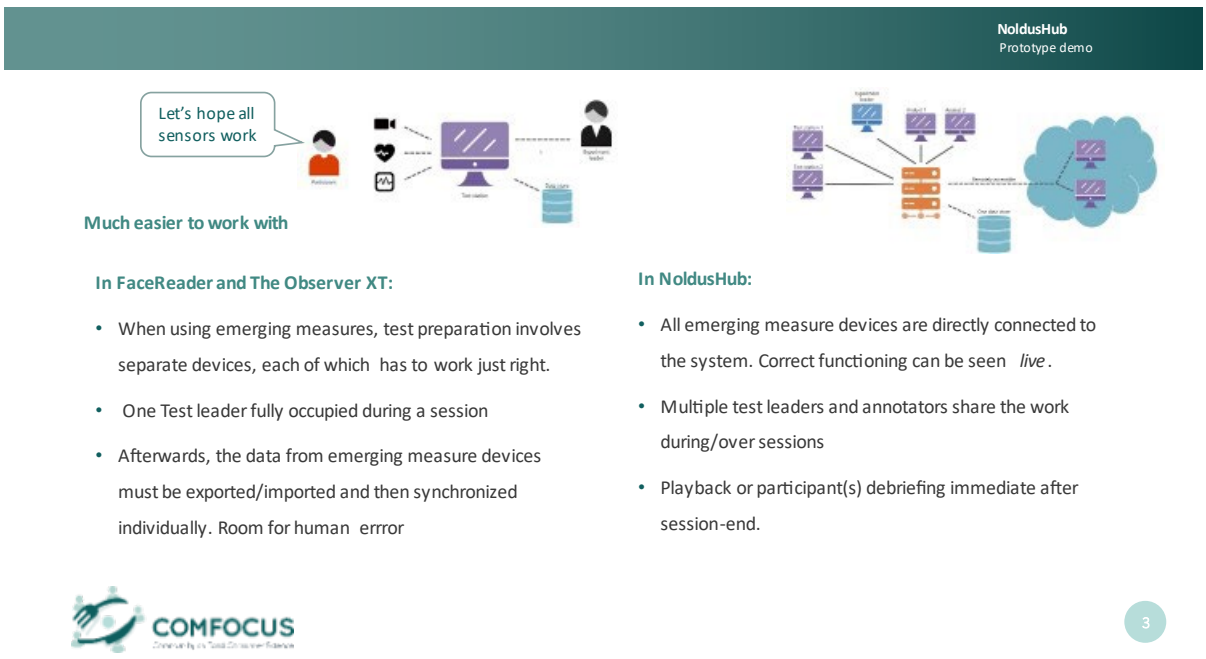
The start and end recording times of the recording device must be aligned with those of the other data modalities that are recorded simultaneously. This is difficult to achieve and required disciplined work and attention. Example: The test leader wants to use record the session using a video camera that records to a SD-card. Simultaneously, an Eye Tracker is used to record the user's eye gaze to a stimulus. Finally, a wearable device is used to record the test subject's heartrate during the session.

First all data sources need to be aligned with regard to start-and end times for recording. However, the wearable starts recording at the moment the battery is inserted, the eye tracker is governed by computer 1 (with its own time & day clock) and the video uses its internal time & day clock.

The date/time alignment must be sub--second accurate, which can be achieved in two ways:

a) By aligning all the involved devices through a network, but this requires additional technical skills from the experimenter.
b) By letting each device have its own Time & day clock, but introduce an event that is detectable in all the to be recorded data streams. For instance letting the participant shake an arm (detectable by video) while holding breath (detectable by wearable). The first appearance of a stimulus (detectable in both the video and the Eye tracker stimulus presentation) ensures that all three data streams can be aligned in time on the synchronizing event. This however is subject to human error and difficult to achieve with sub-second precision.
c) Additionally, not every device has the same precision in keeping time. For longer sessions this leads to a gradual misalignment of the various data streams.
d) Finally, if during a session any one of the devices (temporarily) stops functioning (for example, a cable gets disconnected, a battery runs out) then the whole session is effectively lost, since this probably was not noticed in time and even if it was, a gap in one of the data streams makes it very hard if not impossible to synchronize the restarted data streaming the session.

All this require so many technical skills that using these measures in experiments is often considered not worth the effort and risk of bad data. Yet because these measures are really believed to contain valuable insights, such attempts are made more and more, which is the reason to call them 'emerging measures'.



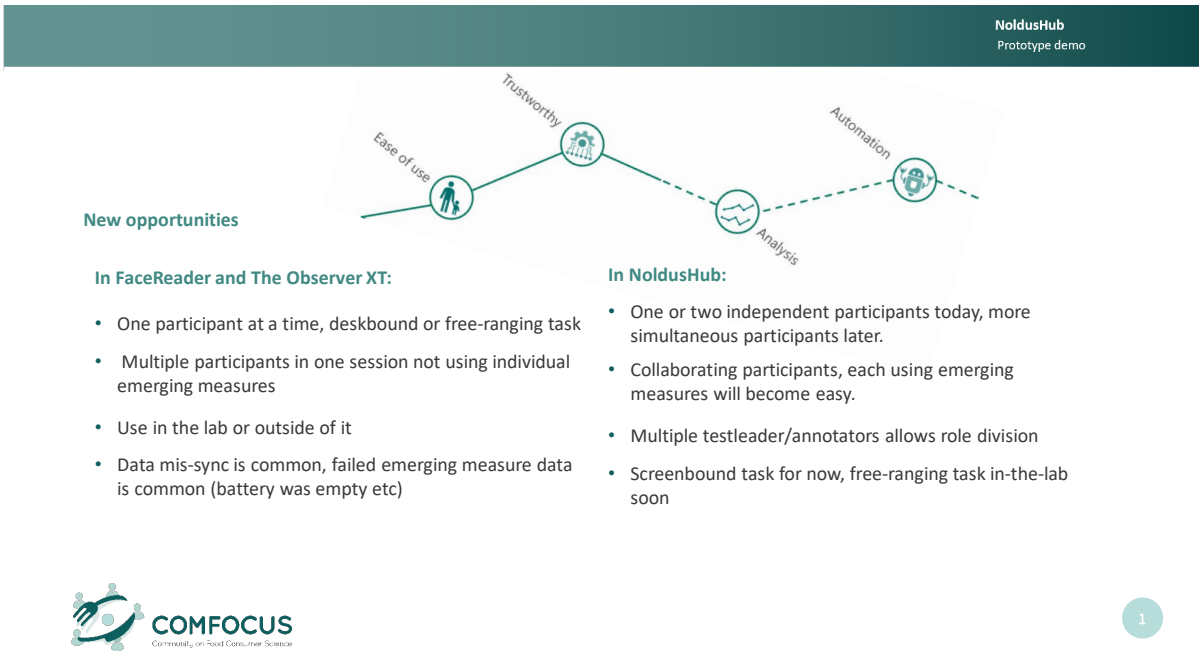
With NoldusHub, Noldus plans to make working with emerging measures much easier. All to be used devices are connected to the system before the first session. Via cables. if possible, or wirelessly if need be. These devices come together at the participant station, where arriving data is given a shared timestamp. No more intermediate and separate recording computers. This solves the start-and stop recording time alignment of the disparate data

streams. It also recovers synchronization, when a data stream unexpectedly restarts or is temporarily disconnected.

Furthermore, because of the live connection to the sensor devices/recording devices during the session, the test leader is warned proactively about low batteries or disconnected cables. He can act on such alarms before and during the session, and the remainder of the session can be either aborted or restarted. This is much better than with the existing ways of working, where the usefulness of the recorded data is only known after the participant has left the building. NoldusHub thus integrates:

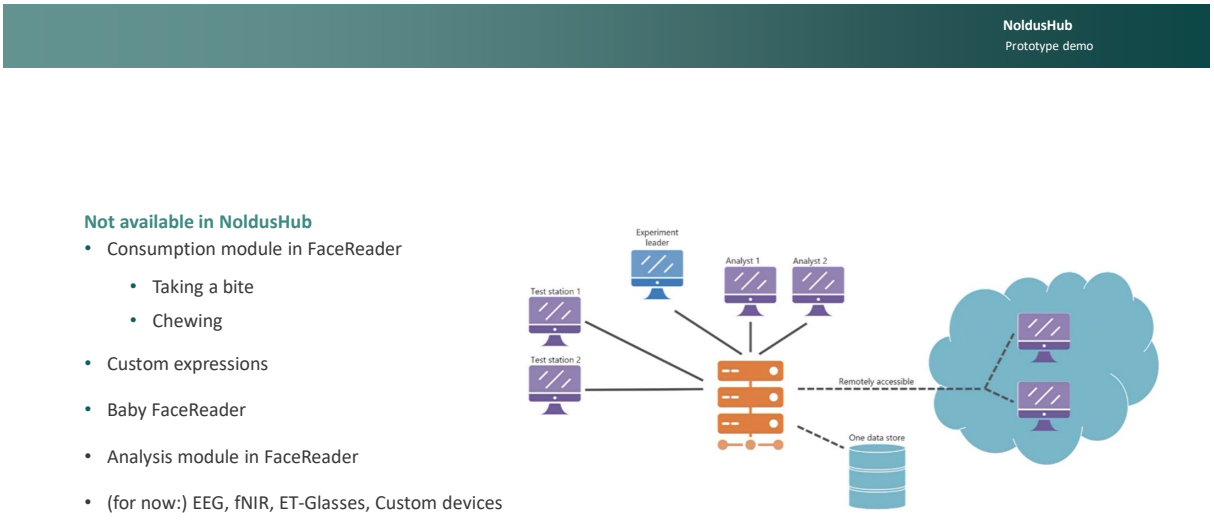
- Screen capture of the screen-based stimulus (video, a program, a webpage, any stimulus that can be shown on a computer screen)
- Overlay eye gaze plot to see where on the screen the participant was watching (several makes of eye tracker)
- Webcam video of the participant's head and face during the session
- Emotion detection from webcam
- EDA/GSR detection from Shimmer GSR+ wearable
- Heart rate and Heart rate variability detection from Shimmer GSR+ or ECG wearable

It does this data integration live and during playback. Before and while recording a session, NoldusHub informs the test leader, when sensors are working ok, current battery charge, sensors operating outside the sensible range (so called Clipping). Events of interest can be marked (annotated) during a live session or during replay. Because the test leader no longer has to give all his attention to ensure the success of one session, in some experiments it becomes possible to share attention between simultaneous participants: while one participant is recording in a session, another can be briefed or debriefed. Alternatively, a test leader can use NoldusHub even while another test leader is using it for his own experiment simultaneously.



The demonstrated prototype is currently restricted to one or two simultaneous participants. This limitation demonstrates the proof of concept without detracting development by worrying about system performance. By design, this can be scaled up easily but it will no doubt increase the need for development attention to performance of the system (and increase cost price) and may increase the workload of the test leader. Whereas the prototype allows two simultaneous participants, each parallel session is considered as stand-alone. With added functionality, this can be changed so that participants collaborate in a task, that is: the behavior of one participant is influenced by the behavior of another participant, or they accomplish a task together, and the emerging measures of all involved participants are recorded simultaneously. This conceptually allows analysis of their behavior as a team and/or as an individual in that collaborative task.

If the test leader becomes too busy briefing or debriefing participants, or analyzing live or replayed data, then she can delegate work to coworkers. This way, a coworker could mark moments of interest during a session, while the session is ongoing, or in sessions that were completed and at the same time the test leader might do the same with another live participant or might be setting up a new experiment. New developments would add Mobile eye tracker glasses, allowing the participant to free range in the lab –within wireless range of the participant station.



NoldusHub is built upon existing Noldus products with their existing functionality. The thinking in product positioning today is, that NoldusHub makes using emerging measures much easier, allowing much more research to take place by scientists less technically skilled. That still leaves researchers that have the technical skills to use the products today. Noldus will continue to add functionality to the existing products, thus letting NoldusHub be an addition to the product portfolio rather than replacing the existing product. The existing products will satisfy the expert needs of some scientists.

As NoldusHub is used more and more in behavioral science domain, Noldus will learn what extra common, expert or novel capability is needed inside NoldusHub to suit the Noldus customers even better. This will govern the priority of future development. For now it makes sense to consider EEG, functional NIR, Eye tracker glasses and a standardized way to connect with custom devices as upcoming connectivity, but this already competes with the many other facets of desired functionality such as data analysis, novel algorithms, regions of interest for eye tracking, use of the participant station over internet … and many more wishes and ideas.

NoldusHub
Prototype demo

Possible uses in Open Call 2

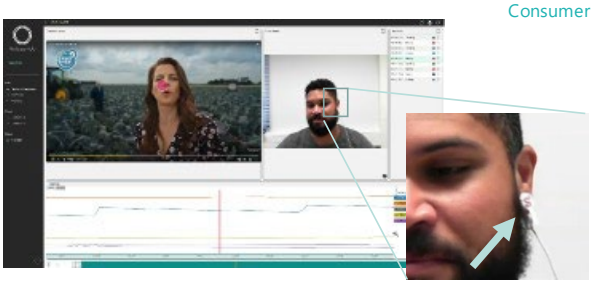
Emerging measures covered in the T6.1 guideline

Equipment : W10-server, W10 desktop(s), router, emerging measure devices of choice (see below)

- Shimmer wearable
  - Heart Rate (HR), Heart Rate Variability (HRV)
  - ElectroDermal Activity (EDA)
- Facial Expressions/emotions (FER) from Webcam
- Desktop eye tracking (ET) from Tobii or EyeTech
- HD Stimuli on computer screen (Images, video, Web pages, Interactive software)

Application areas

Psychology
Medicine
Zoology
Human Factors
Neuroscience
Consumer Science
Sports



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The NoldusHub prototype can be used by COMFOCUS TNA sites but since it is a novel measuring device, care should be taken that all COMFOCUS efforts stand or fail with the success of this delivery. It is better to spread the risks and use NoldusHub in one TNA site. Since both WUR and Noldus have their residence in Wageningen (NL), it makes sense to start discussion on how NoldusHub can be installed at TNA WUR soon. By experiencing the prototype's possibilities and restrictions for FCS experiments, in combination with sensor devices already present at WUR, the emerging measures of task 6.1 HR, ET, FER, and EDA can all be used either with existing WUR equipment or with NoldusHub. This use at WUR during Open Call 2 is work in progress.

Right after this presentation, The prototype was demonstrated at the COMFOCUS Annual meeting by Tobias Heffelaar while in Porto, Portugal. Test subjects were briefed at the Noldus premises in Wageningen (NL). We could all see the data bing recorded in the lab (in NL) while Tobias controlled the session from abroad.
This concept of remote controlling a locally prepared experimental set up fits well with current ideas for Open Call 2, which involves international test leaders performing experiments in selected COMFOCUS TNA sites.

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