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DATA NOTE

Dataset of workers physiological signals during assembly tasks

[version 1; peer review: awaiting peer review]

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v1 **First published:** 08 Aug 2026, **6**:284
https://doi.org/10.12688/openreseurope.24614.1
Latest published: 08 Aug 2026, **6**:284
https://doi.org/10.12688/openreseurope.24614.1

Abstract

Workers in manufacturing environments are frequently exposed to demanding working conditions that can affect both their performance and overall well-being. However, due to the challenges associated with collecting high-quality physiological data in real industrial settings, publicly available datasets remain scarce, limiting the development of human-centric and affective computing applications for manufacturing.

To address this gap, this work presents a dataset of workers' cardiovascular and ocular signals collected while performing operations in a semi-automated assembly line at the facilities of Silverline Endustri Ve Ticaret A.S. (Silverline). The assembly line is composed of a human-robot cooperative workstation and a manual workstation where operators perform quality control and packaging operations.

The dataset contains over 9 hours of cardiovascular and ocular measurements from four operators, linked to assembly operations. By making this dataset publicly available, the authors aim to facilitate access to physiological data for the development of human-centric industrial solutions that support workers' well-being and advance affective computing research in manufacturing.

Plain Language summary

Manufacturing workers often perform tasks under demanding conditions that can affect their health, well-being, and task performance. Understanding how workers respond to these conditions can help industry and researchers develop technologies that better support people in their jobs. However, collecting physiological data in real industrial environments is challenging, and

Open Peer Review

Approval Status *AWAITING PEER REVIEW*

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there are few publicly available datasets on this topic.

This Data Note presents cardiovascular and ocular data collected from four workers performing manual and human-robot cooperative tasks in an assembly line. The dataset includes information related to heart activity and eye behavior, recorded using a chest band that monitors heart rate and eye-tracking glasses while workers performed quality control and packaging tasks.

By making this data publicly accessible, we aim to support researchers working on human-centric manufacturing, worker well-being, and affective computing. The dataset can be used to test new methods of understanding workers' responses in real industrial scenarios and for designing technologies that consider human needs.

Keywords
Industry 5.0, human-centric, human factors, physiology, heart rate variability, eye tracking, affective computing, manufacture



This article is included in the Horizon Europe gateway.

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Author roles: Toichoa Eyam A: Conceptualization, Data Curation, Formal Analysis, Investigation, Methodology, Resources, Software, Validation, Visualization, Writing – Original Draft Preparation, Writing – Review & Editing; **Canbul G**: Conceptualization, Investigation, Resources, Writing – Review & Editing; **Gün O**: Conceptualization, Investigation, Resources, Writing – Review & Editing; **Talaş E**: Conceptualization, Funding Acquisition, Investigation, Resources, Writing – Review & Editing; **Martinez Lastra JL**: Conceptualization, Formal Analysis, Funding Acquisition, Investigation, Project Administration, Supervision, Writing – Review & Editing

Competing interests: No competing interests were disclosed.

Grant information: This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No [101058589] [AI Powered human-centred Robot Interactions for Smart Manufacturing (AI-PRISM)].
The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

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How to cite this article: Toichoa Eyam A, Canbul G, Gün O *et al.* **Dataset of workers physiological signals during assembly tasks [version 1; peer review: awaiting peer review]** Open Research Europe 2026, **6**:284 https://doi.org/10.12688/openreseurope.24614.1

First published: 08 Aug 2026, **6**:284 https://doi.org/10.12688/openreseurope.24614.1

Introduction

Industry 5.0 emerges as a key driver for utilizing research and innovation to create a more sustainable and human-centric industry.[1] Creating a human-centric industry requires developing human-aware systems capable of understanding and adapting to workers. Human-aware systems rely on data-driven frameworks and technologies, such as AI-based methods, digital twins, and affective computing, to model, monitor, and respond to human states and behaviors. Therefore, to develop realistic industrial human-aware systems, it is essential to collect data that enables a better understanding of workers' state.

At the workplace, workers' actions and behaviors can be influenced by their emotional and cognitive states.[2] Thus, human-aware systems should be trained with information that allows them to interpret and react to workers' internal states. In this area, physiological activity provides great information about the internal status of workers. Physiological signals can be processed to derive states such as stress or attention, which can then be used to improve workers' interaction with industrial entities such as robots.[3]

Currently, it is common to find industrial data from PLCs, robots, or navigation maps. On the other hand, it is difficult to find open-access physiological data from workers performing industrial activities. Majority of the available open-access sources of physiological data have been collected in controlled scenarios such as laboratories, and in contexts not related to industry. This dataset aims to fill this gap by providing recordings of physiological signals of four operators working in a quality control and packaging station of an assembly line. The dataset contains cardiovascular and ocular activity signals recorded while the operators executed tasks in a cooperative and a manual workstation.

Finally, this dataset has been collected and generated within the scope of the AI Powered human-centred Robot Interactions for Smart Manufacturing (AI-PRISM) project, which aims to improve human-robot interactions by making machines aware of workers current and future activities within the workplace.

Materials and methods

Data collection scenario

This dataset was gathered in a real-world assembly line located in Silverline Endustri Ve Ticaret A.S. (Silverline) facilities, a partner from the AI-PRISM project that manufactures home appliances. The data collection was conducted in the last section of the assembly line, in charge of the quality control and packaging of exhaust hoods. This section is composed of a cooperative and a manual workstation. In the cooperative workstation, the worker interacts with two collaborative robots (cobots) to perform the quality control of exhaust hoods. In this workstation, the operator cooperates with the cobots performing tasks such as pick and place, visual inspection, or grounding test. On the other hand, a second worker is located at the manual workstation to complete the process by assembling the filter, cleaning, and packaging the exhaust hoods. Figure 1 illustrates a schema of the operations performed in this section of the assembly line.

The assembly workflow proceeds as follows. First, the exhaust hood is transported along the conveyor until it is picked up by the operator. The operator picks up the hood and places it in the fixture in front of a cobot. Next, the operator connects the hood and activates the cobot to perform a visual inspection for defects. Once the inspection has been completed, the operator places a barcode inside the hood and transports it to the fixture in front of the second cobot. After fixing the hood, the operator activates the cobot to perform the functional tests (grounding, isolation, and high-tension tests). When finished, the operator unplugs the hood, tucks the cable, and returns the hood to the conveyor. When the hood arrives at the second operator, they assemble the filter and metal label, clean the product, package it, and attach a label to the packaged product.

Participant recruitment and ethical policies

A total of four Silverline workers volunteered to participate in the data acquisition sessions. All workers were female, between 25 and 38 years old. Participants were not instructed to abstain from coffee, tea, smoking, or engaging in physical exercise prior to the data collection to preserve their typical routines. Written consent was obtained from all participants prior to the data collection. Furthermore, since the study involved human subjects and the collection of video recordings and physiological data, an application for ethical review was submitted prior to data collection. The Academic Ethics Committee of the Tampere Region approved all ethical and experimental procedures and protocols under the Statement 165/2023, performed in line with the GDPR and EU/institutional ethics codes.

Data collection

The data collection took place over two weeks in Silverline's facilities. The workers were equipped with wearable devices to record their physiological activity during task execution. During the duration of the experiments, data from all four

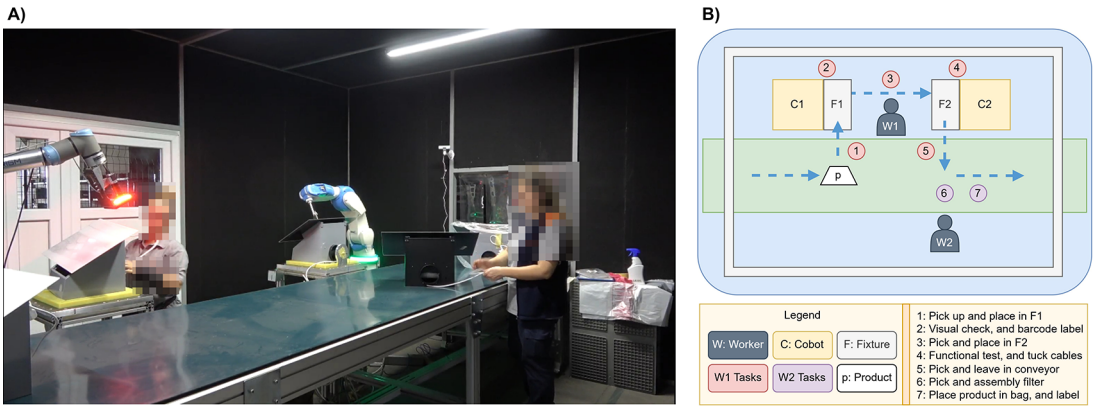

Figure 1. Quality Control & Packaging Section Layout. A) Real-world assembly line. **B)** Operational workflow diagram.

workers were collected in both the cooperative and manual workstations. Workers performed under their regular working conditions to capture the range of variations they typically experience in their work routine.

Two different wearable devices were used to record workers' cardiovascular and ocular activity. Cardiovascular activity was recorded using the Polar H10 chest band, which has a sampling rate of 130 Hz. On the other hand, ocular activity was collected with Pupil Invisible glasses with an eye-tracking sampling rate of 200 Hz.

During the recording sessions, the eye-tracking glasses experienced overheating issues. To prevent data loss, recordings were taken in intervals of 20–30 minutes. Additional refrigeration periods were required during which workers continued their tasks, but eye-tracking data was not recorded. Therefore, the released dataset includes only time periods for which both the Polar H10 chest band and the Pupil Invisible eye-tracking glasses were working simultaneously. As a result of this situation, the last worker has less available data than the rest. Despite the overheating problems, it was possible to collect approximately 9 hours of data recording.

Data processing

To ensure synchronization between wearable devices, all video and physiological data streams were recorded using iMotions software.[4] Each recording session was segmented by assembled product, and each assembled product was further divided into assembly steps using timestamp markers. An Area of Interest (AOI) corresponding to the operator's visual work area was defined for each assembled product. Eye-tracking and electrocardiography metrics, including fixations, saccades, blinks, heart rate, and R-R intervals, were exported from iMotions in.csv format. The exported files were then processed using programming tools such as a Python/Jupyter Notebook pipeline to organize the data by recording session, assembled product, and assembly step, while handling missing values, outliers, and data inconsistencies. The resulting dataset contains timestamped ocular and cardiovascular measurements for all recorded sessions.

Ethics approval and informed consent

All ethical and experimental procedures and protocols were reviewed and approved by the Academic Ethics Committee of the Tampere Region on November 20th, 2023, under the Statement 165/2023 concerning a statement request 51/2023 "AI powered human-centred robot interactions for smart manufacturing AI-prism – psycho-physiological signal sensing for emotional-cognitive modelling: assessing skill levels and avatar generation", following the ethical principles and guidelines defined by the Finnish National Board on Research Integrity (TENK). Before starting the data collection, all the participants were informed about the purpose of the study, its procedures, and their rights as participants, and the measures implemented to ensure their privacy and the confidentiality of their data. Participants gave written informed consent, confirming their voluntary participation in the study and their right to withdraw at any time.

Data availability

The data collected during the study is publicly accessible at Zenodo on https://doi.org/10.5281/zenodo.17658957.[5]

The dataset is structured as follows:

- **001(.zip) – 004(.zip):** refers to the identification code assigned to each participant. Each.zip file contains four folders: blinks, ecg, fixations, and saccades.

- **blinks**: This folder contains the .csv files from the different recording sessions in which the worker participated during the study. Each of these.csv files contains data related to the blinks of the worker during the corresponding session.

- **ecg**: This folder contains the .csv files from the different recording sessions in which the worker participated during the study. Each of these.csv files contains data related to the electrocardiogram (ECG) of the worker during the corresponding session.

- **fixations**: This folder contains the .csv files from the different recording sessions in which the worker participated during the study. Each of these.csv files contains data related to the fixations of the worker during the corresponding session.

- **saccades**: This folder contains the .csv files from the different recording sessions in which the worker participated during the study. Each of these.csv files contains data related to the saccades of the worker during the corresponding session.

The.csv files are structured into columns corresponding to specific features of their own nature (blinks, electrocardiography (ECG), fixations, or saccades). Additionally, there can be found generic identifiers such as

- Worker ID: Identification code of each participant.

- Experiment Name: Name given to the recorded session.

- Event Label: Task of the assembly process that the worker was executing at that timestamp.

- Event Group: Number of the assembled product relative to the session. In blinks, fixation, or saccades, it could also refer to whether the worker was staring at the product's working area or at another worker.

- Start: Time when the event described in *Event Label* begins.

- End: Time when the event described in *Event Label* finishes.

- Timestamp: Time when the data stream was recorded.

The dataset is licensed under Creative Commons Attribution 4.0 International (CC-BY 4.0) Public Domain Dedication license.

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