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WEBA dataset as the Reflection of Work content effect on Workload perception in Real life Working conditions

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The effect of work content on workload, stress, and performance was not well addressed in the literature, due to the lack of comprehensive conceptualization, problem definition, and relevant dataset. The gap between laboratory-simulated studies and real-life working conditions delays the generalization, hindering the development of performance management and monitoring tools. Contributing to this topic, a data collection effort is organized, which considers unique work conditions and work content factors of a coffee shop, to conceptualize scenarios that better highlight their effect on human performance, thus creating the Work content Effect on BAristas (WEBA) dataset. Utilizing sensor technologies to recognize the ongoing activities, physical work activities and heart rates of five baristas in 55 shifts with different work content combinations during real-life working processes were recorded, while the integration of subjective and objective measures of workload and emotions were deployed as perceived workload indicators. Heart rate signals during normal conditions without working were measured as the baseline. This dataset is unique in its conceptualization and useful for scrutinizing more nuances of the effect of work content on performance and the well-being of employees, as well as facilitating better human factor engineering, workplace and work task design.

Background & Summary

Within any occupational position, workers can perceive psychological stress (hereinafter referred to as "stress") from the physical environment, the work setting which is known as work context, and the work content which is the demand of assigned tasks[1–4] (https://www.who.int/news-room/questions-and-answers/item/ccupational-health-stress-at-the-workplace). Since the first two sources have stable effects and can be well-monitored, the physically or psychologically demanding work content that exceeds the work abilities or resources of an individual then becomes a dominant stressor[5–7], directly causing high perceived workload, physiological stress, physical symptoms and even fatigue[3,8,9], that negatively impacts productivity performance, well-being and health[7,10–14]. Aligning with the International Organization for Standardization (ISO) standard of developing an Occupational Health and Safety (OHS) management system[15], studying the effect of work content on workers will enable better work design, human factor engineering, task allocation, and even real-time workload monitoring[16–18], thus achieving better human performance and centricity within both Industry 5.0 (I5.0) and Society 5.0 concepts[19,20]. However, further studies on the effect of work content to obtain these goals are suffering from barriers that should be addressed.

The first gap is the lack of conceptualization of work content factors as stressors[21], as many studies on occupational stress only considered workload from a profession as a whole, without a clear separation of effect from work context factors and/or the physical environment[22]. Regarding the work content, several studies focused only on environmental stress, and physical, or mental workload[2,23–25], without elaborating on their elemental

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and collective effect. On the other hand, the momentary characteristic of the work content is frequently undermined and neglected, thus does not support the estimation of its effect in a real-time manner. Some studies on populations of office workers or system operators focused on the moment-to-moment workload[26,27], however, only a simplified approach without a quantifiable elemental workload was considered, with a modest combination of mental and temporal components without physical one, thus the concluded results are limited to explanatory purposes rather than principles to design the work content.

Secondly, different stress types such as acute and chronic stress with associating effects occur under the influence of work content, but a clear separation between them is missing. Acute stress with short duration (e.g., seconds to minutes) can have positive or negative effects[28]. A low level of Acute Work-Content-Related Stress (AWCRS)[21] is associated with stimulated cognitive functioning and work capacity, thus producing optimal performance[29–33], while a higher value or prolonged duration causes more anxiety and risk preference[34,35]. Overloading or long exposure leads to chronic stress with decreased cognitive and physical functioning[36–40]. Many studies claim to recognize perceived workload and stress with real-time monitoring of physiological parameters such as Heart Rate Variability (HRV)[41–44], however, due to the lack of high-level evidence and a well-constructed experiment, none of them can capture and distinguish different stress types and effect, such as the AWCRS[21].

To facilitate more research on this domain, more well-conducted experiments and datasets are needed. The available dataset or experiment generated in a laboratory environment[45–50] limits the practical generalization for other contexts, due to the too-ideal conditions or the combination of unrealistic work content (e.g., higher mental workload than physical one, fixed duration of work content exposure). In contrast, data collected from real-life experiments or field studies[51,52] face challenges to have a well-controlled condition, separable effect from factors in work content, and a detailed log of work activities that supports analyzing the momentary effect.

This study contributes high-level evidence on the effect of work content on human workers, in terms of emotion, perceived workload and stress, and performance. A specific occupation (i.e., the barista) is chosen as the study subject, due to the intrinsic nature of its task. Firstly, the work content mainly comprises repetitive tasks and reflects elemental physical, mental, and temporal components, which can be diagnosed by the number of fulfilled orders and produced cups of drinks. Secondly, as the work sequence is not continuous and there are gaps between incoming orders, the barista has rest time in the middle of the tasks, which allows for examining the momentary effect of different combinations of work content factors, as well as the recovery of the body to the normal resting state after working. With the proposed conceptualization, the working environment in a specific coffee shop is utilized to generate a real-life Work content Effect on a BArista (WEBA) dataset. Thanks to the special properties of this coffee shop with an enclosed space, the effecting factors from its physical environment can be well-monitored in a stable condition. The scale of the shop allows only one barista to work at a time, making this an ideal scenario for studying the effect of work content (i.e., incoming orders) on the individual workload perception and performance, without any interaction or collaboration with coworkers and managers, and similar to a laboratory study with controlled environment. After considerate on-field setups and arrangements, along with a baseline collection of 24-hour Heart Rate (HR) recordings, work activities with HR measurements are recorded for 55 work shifts conducted by five baristas. By providing an exploratory analysis, this paper also exhibited the internal validity and potential of the WEBA dataset for the effect of work content research. Further utilization is highly encouraged to study the in-depth knowledge of human working behavior under work content-related stress. A similar setup can be used to generate real-life datasets from other occupations.

Methods

This study approaches the above-mentioned topic by considering the work content in a specific occupation: the barista. Within this occupation, the work content can be categorized into mental workload as the difficulty of the incoming ordered drinks, physical workload as the frequency and intensity of the physical activities during making and serving drinks, and temporal workload as the required work pace. The work context that also poses stress on the barista includes the interactions with customers, and non-work-content-related activities that are not associated with the number of ordered drinks (e.g., floor cleaning, interaction with the managers). The work environment contains factors that reflect the physical environment, such as working area, ergonomic arrangement, lighting condition, noise, and temperature, etc. As the main object of interest in this study is the effect of work content, the factors from work context and work environment are isolated, thanks to the intrinsic characteristics of a coffee shop that made it ideal for generating the WEBA dataset, as they will be discussed in the next subsections. The generated outcome includes the output as the finished orders from customers, which accumulates in the monetary value of revenue, and the work content effect which is captured with the perceived workload, kinetic signal, and physiological signal of HR. The categorization of the study aspects is illustrated in Fig. 1. The next subsections mention in detail how the experiment setup was constructed for the data collection. This information can be used as a guide for further study analyzing the WEBA dataset.

Work environment. The floor plan of the coffee shop in the study is illustrated in Fig. 2. Due to the small scale of the coffee shop, every barista needs to work alone on every shift, and the main work activities are carried out behind the bar, which can be categorized into two "zones" with pre-defined tasks as follows:

- *Zone 1* is the preparation zone, where the barista takes the order, issues bills, and then performs the plating before bringing the order to customers.
- *Zone 2* is the primary working zone, where the barista makes coffee or drinks, and washes the dishes. There are two areas to prepare the drinks, the *Prep. area 1* and *Prep. area 2*, which are opposite to each other. There is one under-counter three-door fridge under the *Prep. area 1* and the coffee machine, and one freezer to

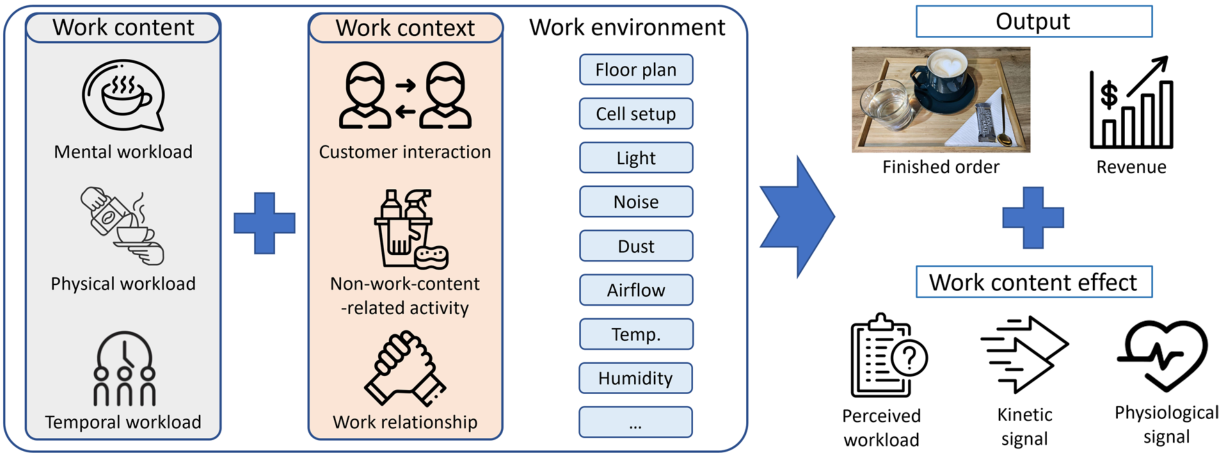

Fig. 1 Categorization of study aspects. The work process is determined as the combination of the "work content" and "work context" within the "work environment", while the result is the "output" in quantity and monetary value, along with the "work content effect" on the barista.

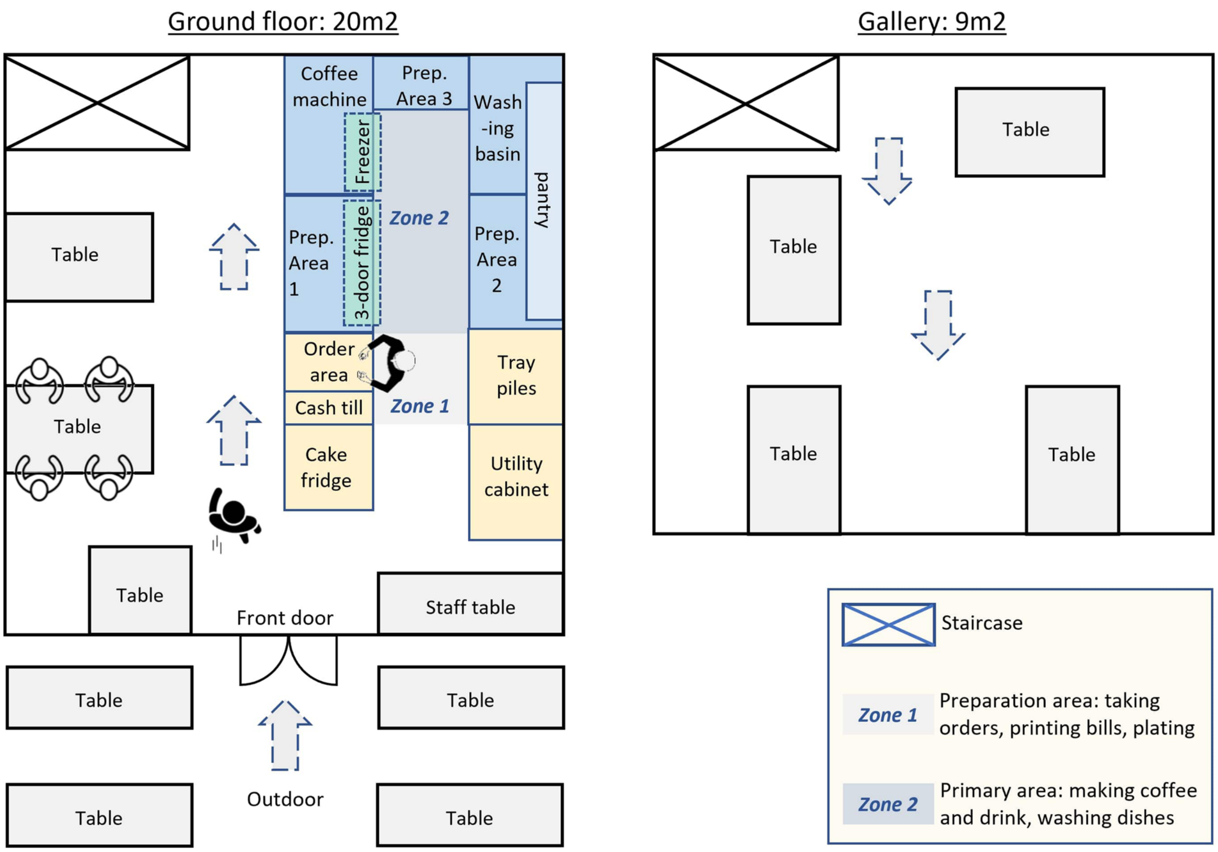

Fig. 2 Floor plan of the coffee shop in the study. The ground floor with indoor tables, working zones, and outdoor tables (left), and the indoor tables on the gallery (right).

store the ingredients such as milk and fresh lemon. The washing basin is on the corner, with the drying rack hanging above.

Outside these zones, the barista will carry out other work-content-related tasks such as serving and cleaning the tables. Other tasks such as sweeping the floor, and preparing the chairs are not work-content-related and will be limited during the data collection periods, as discussed in the next subsection.

As the coffee shop is a closed space, the working environment is stable with the relevant parameters illustrated in Table 1. To avoid effects from the outside environment, data collection is avoided during days with

Name	Value (unit)	Measured method	Controlled condition
Light	58 (lx)	SensorTek STK33911 light sensor on Samsung Galaxy S23	The lighting condition is static during the work with only one main switch.
Noise	66 (dB)	Noise sensor on Samsung Galaxy S23	The coffee shop is located in a deep and quiet alley, with no sound from the street. The only sound in the shop is the repetitive instrumental music.
Dust content	–	–	The coffee shop is located far from the street, in an environment with no dust sources such as construction and insects or animals. There is no dust appearing during the working process.
Airflow	255 (cfm)	Handheld Anemometer	The airflow is regulated by the air conditioner, which is placed on the gallery to avoid direct flow into the working area.
Temperature	23 (C)	Indoor thermometer	Due to the close space and controlled airflow, the inside temperature is stable throughout the whole day within the seasons.
Humidity	–	–	The indoor environment is in normal condition with no significant source of water with an open surface. The humidity is stable thanks to the air-conditioner.
Odour	–	–	There were required cleaning activities at the beginning and the end of the working day, thus no annoying odour can occur.

Table 1. Parameters of environmental condition in the coffee shop.

Fig. 3 The work environment in the coffee shop. (**a**) The look of the ground floor of the coffee shop from outside through the front door, with outdoor tables. (**b**) The gallery with four tables and the air conditioner is attached to the wall. (**c**) The bar counter is divided into two working zones marked by dotted yellow lines, and one barista is working with the coffee machine in Zone 2. The cake fridge stands next to the cash till in Zone 1 and the opposite of the utility cabinet. (**d**) The staircase is in the corner of the ground floor, while the lighting comes from the built-in LED system in the ceiling.

extreme weather such as too-high or too-low temperatures, rain, and snow. Figure 3 shows the pictures of the work environment with designated zones.

The main work cell in *Zone 2* is arranged in a determined layout as illustrated in Fig. 4, with fixed positions for materials, machines, and tools within the reach distance for convenience. The main work surfaces are at 90 centimeters, a convenient height for light work[53]. All baristas are trained with the same work sequence and thus maintain the same layout throughout their working sessions. In the framework of this study and before data collection, a Lean expert is deployed to assess ergonomic risk factors of the work layout according to RULA (Rapid Upper Limb Assessment) tools, considering that work activities in this zone are mostly upper limb tasks. After rearranging some hard-to-reach items and preparing a sufficient quantity for each tool to avoid searching during work, the final score was 2 on the RULA scale for most of the main activities, except for movements

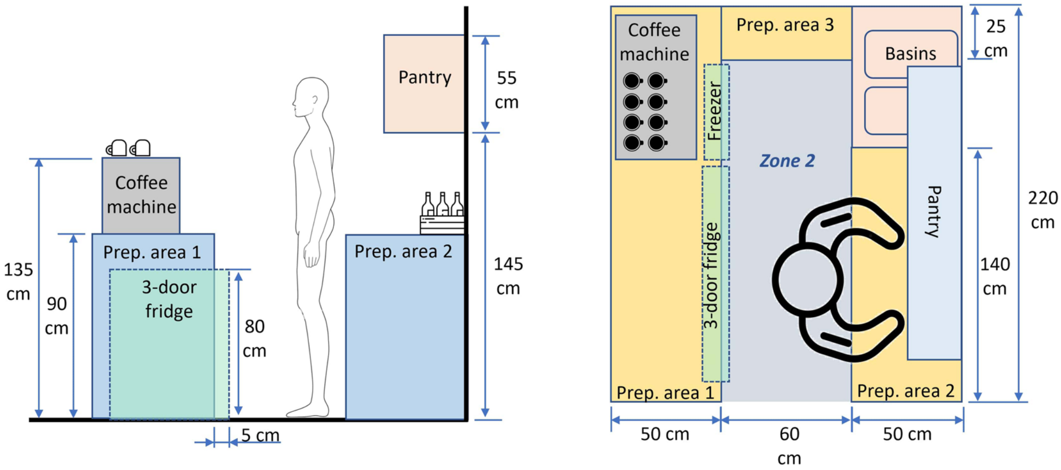

Fig. 4 Details of layout in Zone 2. The side view (left) with the three-door-fridge located under the preparation area 1 and top view (right).

Type	Sensor	Intended usage	Set up	Data acquisition
Fixed sensor	TP-Link Tapo T100	Notify when someone enters the front door, goes through the staircase, or enters the defined zones.	Next to the front door, on the staircase, and the margin of two working zones	Record the movement events as timestamps, transmitted to Tapo H100 Hub via the local wireless network.
	TP-Link Tapo T110	Recognize the opening/closing activity of the front door, the fridge, the freezer, and the cake fridge.	Attached to the hinge of the front door, the freezer, the three-door fridge, and the cake fridge.	Record the opening/closing events as timestamps, transmitted through Tapo H100 Hub via the local wireless network.
	Raspberry Pi with Adxl345 3-Axis Digital accelerometer	Recognize the operations being carried out on the coffee machines.	Attached to the coffee machine with a 25 Hz sampling frequency.	Record a time series, stored in local memory, and transmitted to a personal computer through an SCP connection.
	TP-Link Tapo H100 Hub	Receive the signals from other TP-Link Tapo sensors, stored in a log file.	Placed within the local wireless network.	Data copied to a personal computer through Rust API Client via the local wireless network.
Wearables	Polar Verity Sense[62,63]	Record the Heart Rate (HR) of the barista during work.	Worn on the non-dominant hand, record the beat per minute (bpm) sampled at 135 Hz.	Record a time series, stored in the local memory of the device, extracted through the Polar flow mobile application.
	BMI270 sensor in MetamotionS[64]	Record the acceleration of the hand movement of the barista during work.	Worn on the dominant hand, sample at 12.5 Hz.	Record a time series, stored in the local memory of the device, extracted through the MetaBase mobile application.
	Bosch Sensortec accelerometer in iPhone XS Max	Record the body acceleration of the barista during work.	Set at 25 Hz sampling frequency, and put in the apron.	Record a time series, stored in the local memory of the phone, extracted through the Sensor logger mobile application[65].

Table 2. Deployed sensors for activity recognition.

when the barista needed to bend the trunk down to get the raw materials that are kept in the three-door fridge and freezer located under the *Prep. area 1*, or to take a cake out of the cake fridge. These awkward postures pose an additional but unavoidable load on the barista, in addition to the main physical activities of making drinks. These postures can be recognized with the corresponding sensors for door opening and closing activities, as described in the following paragraphs.

To comply with the General Data Protection Regulation (GDPR), no video or image was captured. Instead, sensors were installed with fixed locations within the working environment to facilitate activity recognition of surrounding events, while wearables were equipped on the barista to recognize the performed activities. The technical specification and intended usage of all these sensors are explained in Table 2, while the installed positions are illustrated in Fig. 5.

Work content and work context. *Work content.* In addition to the setup work environment, the work content and work context factors are categorized in this section. According to the World Health Organization (WHO)[3], the work content includes demands activities and the consideration of assigned tasks, while the work context is the background other than activities related to the work content[3]. In this study, the categorization is done as follows:

- Work content: The factors belonging to this group come from three constituent requirements that represent the work of a barista: physical and temporal workload (as inspired by the work of Berlin *et al.*[54]), along with mental workload (as the workload measured by subjective methods[55]). These requirements are closely associated with the number and frequency of incoming customers, and the required type and quantity of coffee cups made.

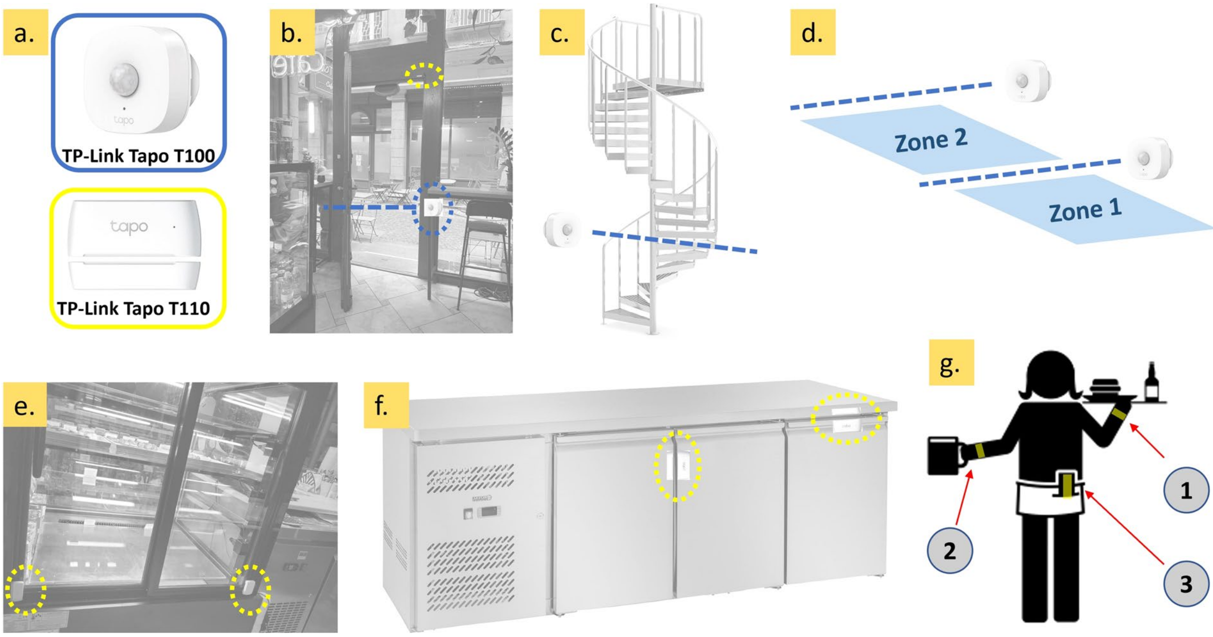

Fig. 5 The fixed and wearable sensors deployed in the study. (**a**) The motion sensor Tapo T100 and door activity sensor Tapo T110. (**b**) One Tapo T100 (blue circle) with its active zone (blue line) and Tapo T110 (yellow circle) is attached to the front door. (**c**) One Tapo T100 is attached to the staircase. (**d**) Two Tapo T100 are attached in the boundary of the defined Zone 1 and Zone 2. The barista is recognized as standing in a zone if there are a couple of entering and leaving events. (**e**) Two Tapo T110 are attached to two hinges of the cake fridge. (**f**) Two Tapo T110 are attached to the hinges of the three-door fridge. Any open activity from each door can be detected. (**g**) During the working session, the barista wears one armband HR sensor (1) on the non-dominant hand, one armband acceleration sensor (2) in the dominant hand, and another acceleration sensor (3) placed in the apron.

- Work context: Besides the work content, any other activity and interaction that are not directly associated with the work, but related to the scope of working in the predefined work environment are grouped into the work context category.

As the main focus of this study, the work content is defined beforehand as a part of the experiment design. A typical order consists of a drink, a glass of tap water, and a cake. While a water glass or a standardized cake does not require any special consideration to prepare other than standard steps, the drink does. Based on discussions with the shop owner and the current baristas, the current drink menu is divided into two levels of preparation difficulty: easy and difficult. The coffee-based drinks (mixtures of espresso base with possible flavored syrup, steamed milk, and milk foam) are considered easy by the baristas, with fewer steps and less required attention, while chocolate-based drinks (mixtures of chocolate base) are considered more difficult with more ingredients, thus higher attention is demanded to fulfill the output quality. As the espresso base is processed by the coffee machine and the chocolate base is prepared beforehand and stored in a dispenser, the activities for all order preparation only require physical movements of pushing buttons on the coffee machine or the dispenser, measuring, mixing, whisking, and plating, without any cooking. Details of requirements while preparing orders with these drinks are illustrated in Fig. 6.

Based on the defined work content, it is necessary to recognize the constituent work content-related activities, factors, and interactions, thus estimating their occurrence and effect during a working period, which accumulates into the work content. Three work-content groups of factors can be identified as the work components:

- Physical demand: reflected in the frequency and amplitude of the physical activities, movements, and actions. This demand can be assessed by the number of conducted activities.
- Mental demand: reflected in the difficulties of the types of drinks made, compared to the work experience of the baristas.
- Temporal demand: reflected the impression of rush, induced by the frequency of receiving orders, and the frequency of coming customers.

These process- and barista-centered activities are defined and categorized in Table 3, which allows them to be recognized, or captured from the WEBA dataset. Since the selling prices of items were stable during the study, the generated revenues in each working shift can relatively reflect the work content within that shift. It can be seen that the work content of the barista requires mainly effort from the physical aspect. This group includes the most frequent product-oriented activities, such as taking orders, making drinks, plating, serving, etc. Other

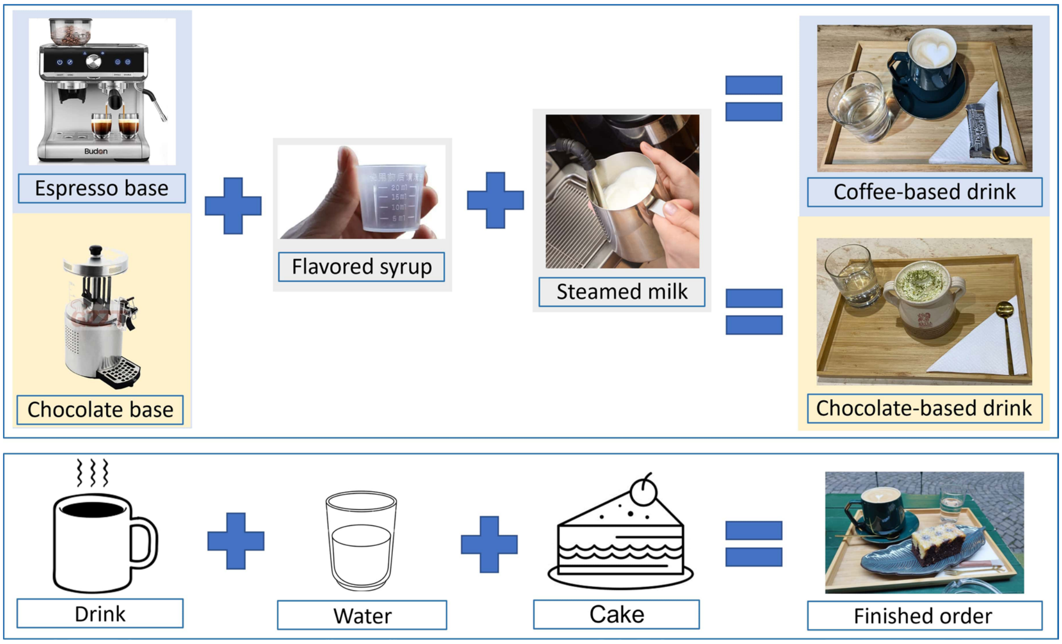

Fig. 6 The components and requirements of typical orders. The requirement of two types of drink: coffee-based and chocolate-based (upper), and a finished order with a drink, a glass of water, and a piece of cake (lower).

Group	Componential activity/factor	Scope	Captured by the acquired data
Physical	Taking orders	Interact with customers, write order notes, issuing bills	Happens when a new customer enters the shop, then the barista enters Zone 1, standing with no body acceleration and small hand acceleration.
	Take out the materials	Take the milk, foaming product from the fridge or freezer.	When the fridge or freezer doors are opened.
	Operate the coffee machine	Prepare the espresso base for coffee-based drinks.	The vibration signals from the coffee machine (several vibration samples labeled with drink type are included)
	Prepare drinks	Perform repetitive handwork of making drinks	When the barista enters Zone 2, standing with no body acceleration and small hand acceleration.
	Prepare the cake	Take the cake from the cake fridge or the freezer.	When the cake fridge doors are opened.
	Plating the orders	Take one tray and place the products on it.	The barista standing in Zone 1 with no body acceleration and has small hand acceleration.
	Serving outside *	Serve or clean ordered tray outside	Bring the tray of ordered products to or from outside tables, with body movement has pulses of walking, leave the working zones, and open the front door.
	Serving outside *	Serve or clean ordered tray outside	Bring the tray of ordered products to or from outside tables, with body movement has pulses of walking, leave the working zones, and open the front door.
	Serving upstairs *	Serve or clean ordered tray upstairs	Bring the tray of ordered products to or from upstairs tables, with body movement has pulses of walking upstairs, going through the staircase.
	Washing dishes	Washing the accumulated dirty dishes.	The barista stands in Zone 2, without body acceleration, and has a small hand acceleration.
Mental	Difficulty level of the orders.	The difficulty levels of the ordered drinks	Based on the order notes collected after the shift, and data extracted from the ordering system.
	Interaction with customers	Mutual communication while taking orders and issuing bills	As this interaction is the intrinsic characteristic of the work, its effect is assessed by questionnaires after the shift.
Temporal	Order frequency	Time intervals between received orders by barista	Based on the timestamps of the registered order in the ordering system $^{\oplus}$, or the operating vibration of the coffee machine.
	Coming customers	A new customer comes in$^{\sharp}$	Timestamps from the opening activities of the front door, when customers step in.

Table 3. Work content factors of the barista in the concerned coffee shop. *: These activities require a pair of two-way commutating walkings. If the barista did not leave the working zones, one activity or both two of the pair were conducted by the customers themselves, e.g., self-serve or take-away orders. $^{\oplus}$: Due to technical reasons, the timestamps of registered orders are missing for the first 13 shift, and available for the last 42 shifts. $^{\sharp}$: During rush hours, customers come and leave after lined up waiting.

Type	Activity - Interaction	Normal frequency	Controlled condition during WEBA dataset collection / Associated characteristics
Activity	Cleaning the shop	Twice per day, before and after opening hours	These durations are excluded from the data collection period.
	Working in collaboration with colleagues	None	Only one barista works at a time with no other colleagues. They only appear in special conditions when the barista feels the workload is unbearable.
	Resting or doing personal work	Frequently, when there is no order	The barista is out of any working zone, has no body acceleration and very small hand acceleration, HR slows down.
	Personal activities	Randomly	When there is no activity in working zones, no sign of new customers.
Interaction	Interaction with managers	Several times per day	The manager is advised not to appear during the data collection, and maintain no contact via phone as well.
	Interaction with colleagues	Once per day, during the shift transition	The transition period of 30 minutes is avoided during data collection.
	Interaction with suppliers	Twice per week	Supplier encounters are avoided during the data collection.
	Interaction outside of work context	Randomly	Participants are advised not to use their phones during the data collection.
	Encounter with unexpected abnormal events or accidents *	Randomly	After the measured shift, if any event is recognized as abnormal or unusual in everyday routine tasks, the data in 15 minutes after that event from that shift will be discarded.

Table 4. Work context activities and interactions during a working session in the coffee shop. *: If the event has a severe effect on the workload perception of the barista, the data from the whole shift will be discarded.

working activities are not significant, such as dispensing the chocolate base from the chocolate dispenser. Since the barista only needs to pull the trigger until fulfilling the measuring cups with prepared marks, no sensor is deployed to recognize it. From the mental aspect, the work content relates to the difficulty of making the orders, considering that all employees were trained in the same way, with a similar standard of product quality. It is assumed that the difficulty of each order creates a different impact on the perceived workload of individual, mainly depending on their work experience in the shop. Regarding the temporal aspect, the intensity of incoming orders with the quantity of each order will create time pressure on the barista. The number of customers coming at the same time exaggerates this time pressure. To highlight the effect of this factor, one can look at the data collected from the beginning of the working shift, when the barista usually can work at a normal speed in comfortable conditions with no time pressure, and no frequent coming customers. During rush hours, customers were coming more frequently. Some of them could not wait to be served, thus they left, and no new orders were recorded. However, their presence still posed a temporal load on the barista. Although the work duration also affects the perception of workload, such as working for long hours can cause additional exhaustion, this factor is not incorporated into the work content, as its effect is limited by assigning fixed work shift duration for every participant during the dataset generation.

Work context. Besides the above-listed activities that are directly related to the work content, the work context contains the other intrinsic tasks that add up to the work content, or the interactions that can generate extra emotional and psychological stimulation during work. These activities and interactions are categorized into different groups as in Table 4. To keep the most steady conditions for focusing on the work content influence and avoid threats to the internal validity (i.e., history factor), extraneous factors such as some activities and interactions are limited, reduced, or avoided during the data collection. For activities that can not be controlled, such as the personal rest duration when there is no customer, its data can be recognized based on associated characteristics.

Workload assessment. To assess the amount of work content within a working shift, objective and subjective measures were taken once the barista finished that shift. The produced revenues and order timestamps extracted from the ordering system at the end of the shift, along with the quantity and type of drinks and cakes were used as an objective measure. During data collection, the menu price was kept unchanged. Though the prices of the cakes vary and do not reflect the actual workload (e.g., the barista does the same activity for serving every cake), the price of drinks somehow represents the required quality level and the preparation activity. The International PANAS Short Form (I-PANAS-SF)[56] was chosen to measure the emotional effect of the workload, while a paper/pencil version of the NASA Task Load Index (NASA-TLX) was deployed to measure the perceived workload immediately afterward the work duration[57]. Details of these measures are mentioned in Table 5.

Human participant. The involvement of human participants, the use of non-invasive sensors in this study, as well as the publication of collected data, are approved by the Ethical Committee of the University of Pannonia, Hungary, under the Decree number KEB_MK_RIT_2023_01. Informed consent was obtained directly from all participants.

To recruit participants for the dataset generation, at first, all baristas who already working in the coffee shop were asked to contribute to a scientific research on well-being in the workplace, without knowing the true research objectives and the purpose of measuring their HR data. Five participants among the baristas were voluntarily involved, with a range of age from 19 to 24, therefore there is no need for parental consent acquisition. Before experimenting, the participants were scanned with a medical history questionnaire, to avoid negative effects from recent disappointments, sleep problems, chronic stress, or hidden diseases (hypertension, diabetes,

Type	Name	Scope	How to measure
Objective	Number of total drinks made	The number of drinks served	Recorded from order notes of the barista and the order system after the measured shift.
	Ratio of easy/all drinks made	The ratio of easy drinks over the total number of drinks made	Recorded from order notes of the barista and the order system after the measured shift.
	Number of cakes served	The number of cakes served	Recorded from order notes of the barista and the order system after the measured shift
	Total made revenue	Total revenue from the measured shift in Hungarian forint (HUF) *	Extracted from issued bills from cash register machine and the order system.
Subjective	Emotion	Positive and negative feelings from work in the shift.	The barista filled out the I-PANAS-SF questionnaire after the shift.
	Perceived workload	The mental, physical, and temporal aspects of work demand, with impressions about performance, effort, and frustration.	The barista filled out the NASA-TLX questionnaire after the shift.

Table 5. Measures to assess the work content. *: During the data collection, the menu price was kept unchanged.

Participant	Gender	Age (years)	Height (cm)	Body weight (kg)	BMI	Work experience (months)	Sport	Meditation
par_01	female	24	163	60	22.6	6	sometimes	never
par_02	female	20	169	65	22.8	2	sometimes	never
par_03	female	24	157	53	21.5	3	sometimes	never
par_04	female	20	162	63	24	4	regularly	sometimes
par_05	female	19	168	59	20.9	11	sometimes	never

Table 6. Information of the participants in the WEBA dataset.

and arthritis) that can affect the study results and the collected HR. Aligning to the company policy, each barista has attended a work capability assessment before they enter the job, and repeated yearly. Based on the examination of licensed physicians, all participants are considered fit for work. According to the proposed body-mass index for the Asian population[58,59], all of the participants are in good physical condition with normal weight.

To protect the personal information of participants, no direct identifier such as living address or mobile phone number was collected. The data were collected under the participant IDs, which were irreversibly anonymized, without disclosing their personal data to the field experimenter. No indirect identifier was collected, no identifiable data was recorded, and no photo or video was taken. The data collected from the user interface of the Polar sensor logger was registered under the name of the investigator. After the principal investigators explained the research procedure and data treatment plan, especially personal data protection, and answered aroused questions, written consent forms were collected from participants for both participating in this research and the distribution of their anonymized data.

The overall background data of participants is described in the Table 6. These participants have different experience levels, identified as the working months before the date of enrollment in the experiment.

Data collection. This section describes the baseline data that are collected from human participants, and deployed methods to make the work schedule and data generation plan.

Collection of baseline data. Once a participant is involved, a baseline collection is performed with two days of 24-hour continuous Heart Rate (HR) measurement, except for the personal hygiene period. One of the two days is a weekday, while the other day is a weekend. Participants were instructed to carry out their daily routines without any abnormal activities.

The HR values of five participating baristas are shown in Fig. 7. These baselines are divided into daytime intervals as "morning hours" (from 8 am to 14 pm), "evening hours" (from 14 pm to 20 pm), and "rest hours" (from 22 pm to 8 am), to create a comparable baseline to the working hours during the measured work shifts. Noticeably, there are some adjustments in the time frame for rest hours, according to the behaviors of the participants during measurements, such as staying late on the weekend. In this case, the "rest hour" started time on the weekend was from 23 pm for the third participant, or 12 am with the fourth participant, to capture their stable HR during sleep. Based on the medical history, these participants are in stable healthy states with their HR value during rest on both weekday and weekend nights showing similar distribution, and has the lowest median value compared to the other daytime periods.

Collection of work shift data. During the planning phase of the data collection, different factors that affect the relationship of perceived workload with the work content were considered:

- The time of work shift during the day: Currently, the coffee shop runs with a schedule of two shifts: morning and evening, each lasting for five or six hours from 9 am and 2 pm, respectively. To avoid the effect of working long hours, each participant can only register to work one shift per day. The measurement always started from the beginning of the shift, after the initial routine cleaning.

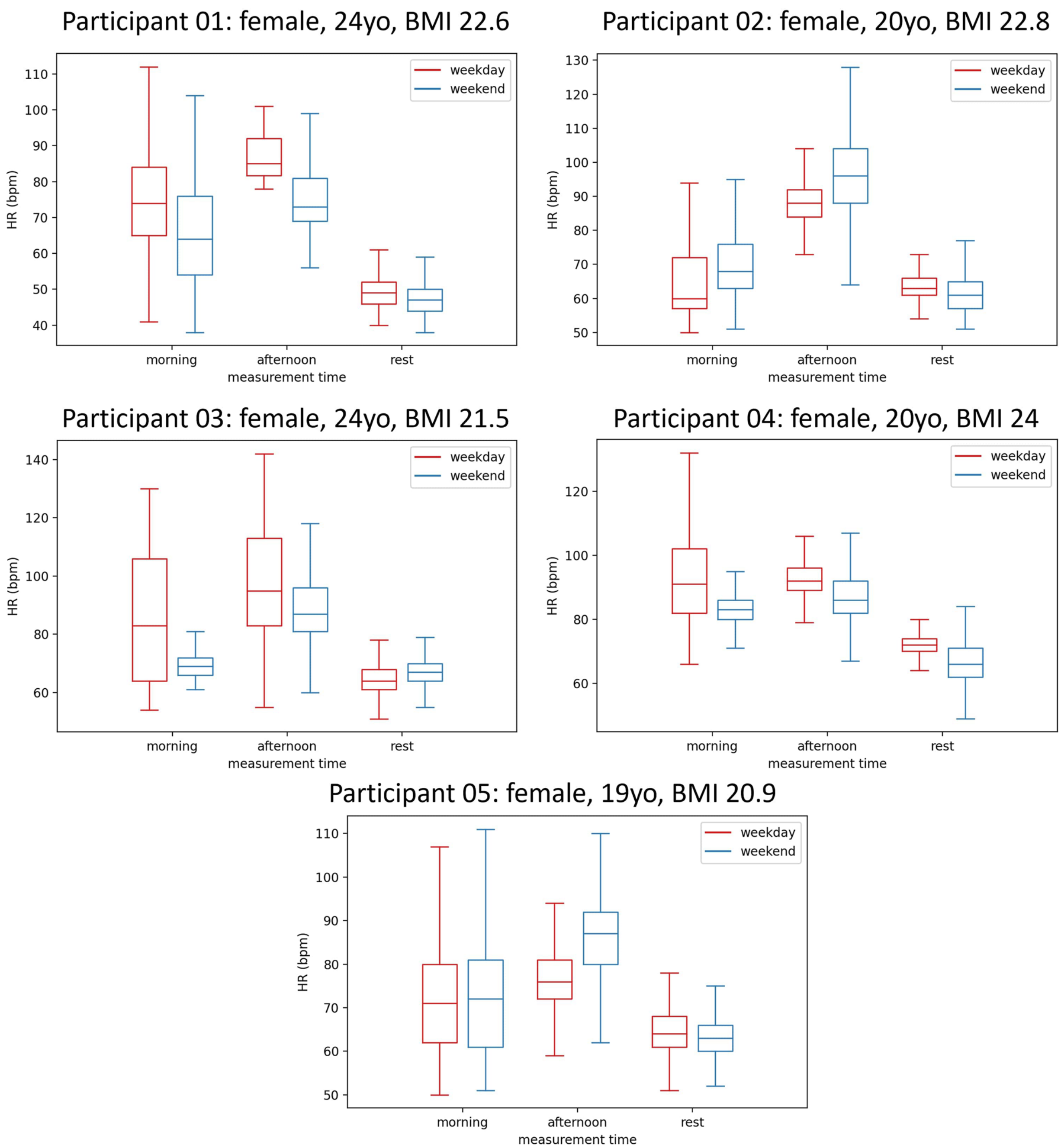

Fig. 7 The heart rate value in baseline measurement of five participants. It can be seen that heart rate during rest time has the lowest median value with less variation. During the day, the median heart rate in the morning is lower than in the evening.

- The number of ordered drinks and generated revenue: As the number of made drinks contributes directly to the amount of required physical drink-making activities, this number is extracted from the Point of Sale (POS) order system after every shift, along with the produced revenue. With approximately the price for every drink being 3.5 USD and for every cake being 2.5 USD (at the time of writing), the revenue after each shift provides a comparable ground for the work content in these shifts.
- The type of drink: since each drink type requires certain experience and processing steps, leads to different cognitive/mental load on the barista, this information is also extracted from the POS system. The coffee-based drinks consist of fewer steps and require less experience, thus being considered easy drinks, while chocolate-based drinks were considered more difficult. Within a shift, the ratio of easy/all drinks may also affect the perceived workload of the barista, as with the same number of drinks made, the higher value of this ratio means more easy drinks were made.

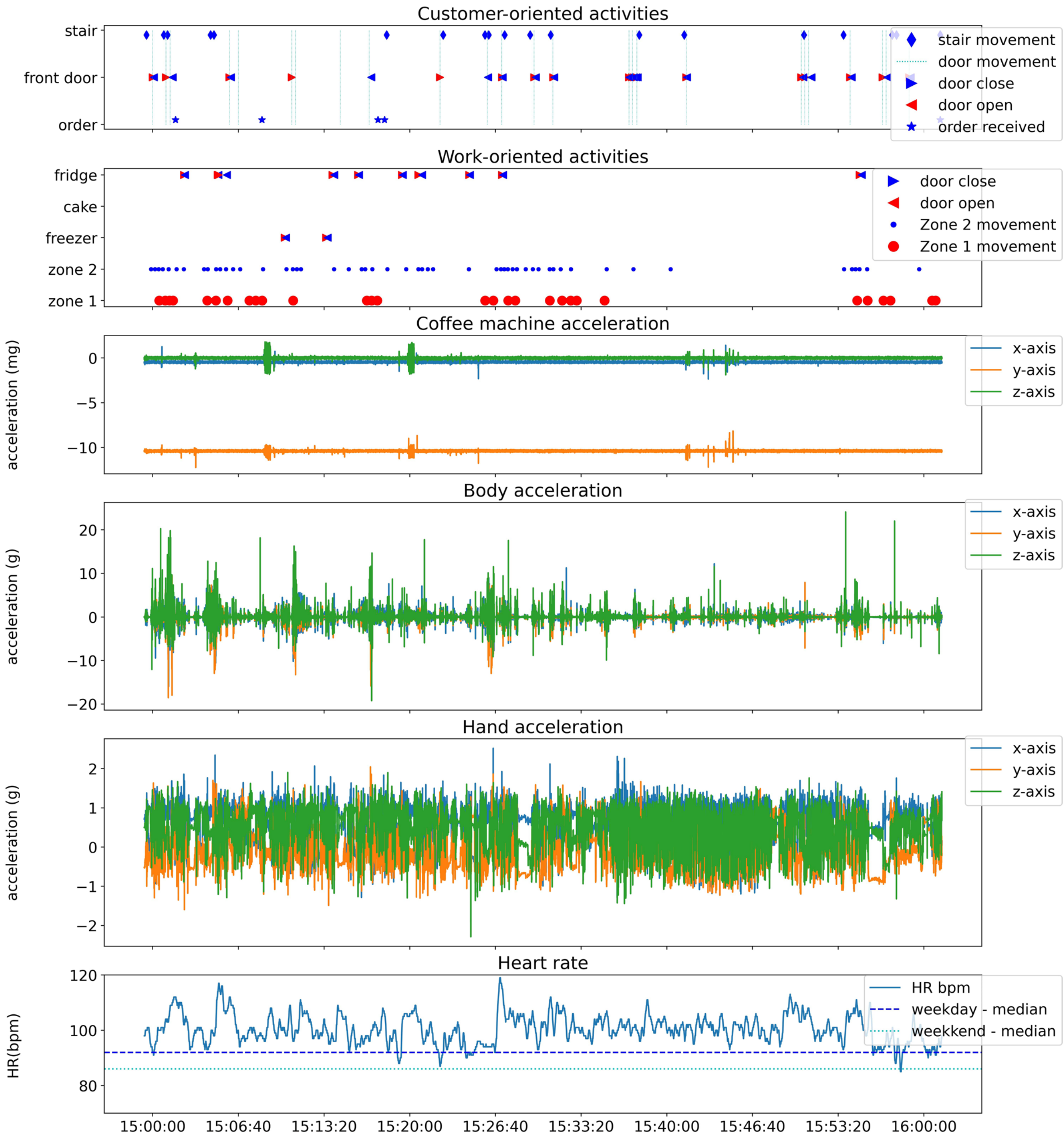

Fig. 8 One hour of raw data between 3 pm and 4 pm from the "20240223_evening" shift conducted by the fourth participant. The produced revenue is 46.725 HUF. This work shift is perceived by the barista as an 18/8 positive/negative score on the I-PANAS-SF scale, with a 78.7 workload score in the NASA-TLX scale, from the work content of 320/70/140 weighted score on the mental/physical/temporal workload, respectively.

Therefore, the investigator tries to create the collection plan with an equal contribution of these above-mentioned factors (e.g., an equal number of morning and evening shifts from each participant). However, in real-life conditions, some factors appeared randomly (i.e., the revenue of a shift, and incoming customers). Therefore, there is no need to perform further randomization, or masking the condition assignment from the participants. Different from a laboratory experiment with a well-controlled environment, this data collection is carried out continuously until the resulting space is filled with the desired factor levels. Although seasonality will not alter the random behavior of incoming customers, it does affect the consumption trend (i.e., more chocolate-based drinks being consumed in cold weather), thus, the measured shifts are also scattered through different seasons to even out this effect. In this way, the sampling and selection bias faded away, and the Hawthorne effect[60] is also neglectable as the participants do not know data from which measured days will be used for further analysis.

During the collection of work shift data, another screening was taken at the beginning of the shift to avoid the possible influence from external factors such as unexpected incidents or events from private life. The

Participant	Baseline duration	Morning shift	Evening shift	Sub-total
par_01 *	15.5 hour (weekday) and 20.75 hour (weekend)	5	1	6
par_02	22.6 hour (weekday) and 27.8 hour (weekend)	8	7	15
par_03	24.75 hour (weekday) and 19.75 hour (weekend)	5	5	10
par_04	24.2 hour (weekday) and 28.5 hour (weekend)	7	6	13
par_05	22.75 hour (weekday) and 25.9 hour (weekend)	7	5	12
Sub-total		32	24	56

Table 7. The details of recorded baselines and shifts in the WEBA dataset. *: During the data collection, this participant was not able to conduct evening shifts due to personal schedule.

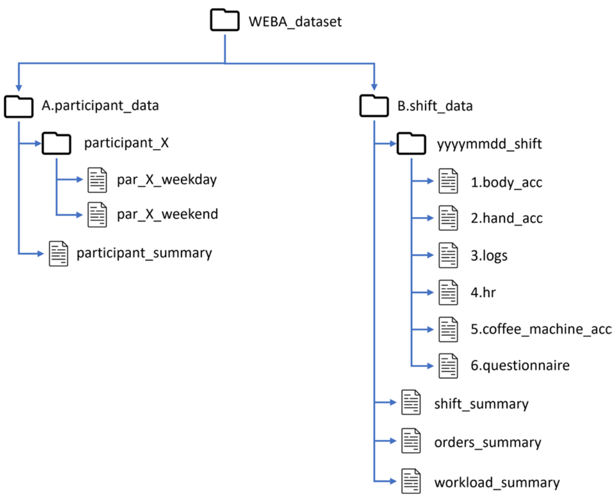

Fig. 9 The WEBA dataset structure. The main folder contains a sub-folder of the background data of each participant (left), and a sub-folder for the measured data after each shift (right). In each of these sub-folders, there are summary files giving necessary data such as the total number of produced drinks, time of arrival of each order, etc.

participants were asked by the manager and the field investigator whether they were in comfortable conditions and willing to participate in the data collection during that shift. Though only verbal screening was conducted in this study, the authors encourage later researchers to deploy a short paper-based questionnaire for this screening purpose. The measurement setup is also arranged during the non-rush moment of the shift, in a way so that once the participants start wearing the wearables, they will have a few (up to ten) minutes of relaxing. Until this point, they had the right to cancel the data collection at any time.

Figure 8 shows the example of one hour of raw data from an evening shift conducted by the fourth barista. The collected data from Tapo sensors can be grouped into customer-oriented events (e.g., opening/closing the front floor, passing the door, placing an order, going upstairs) or work-oriented events (e.g., moving in/out of Zone_1 and Zone_2, open/close the fridge, the cake display, the freezer). The acceleration data were plotted separately for the body and the hand. In the last subplot, the HR value is visualized, with the baseline value on weekdays and weekends of the same participant shown as a benchmark for easy recognition.

As the objective of this study is to collect a dataset that can reflect the effect of work content factors on the workload perception of a working barista, therefore, every participant is encouraged to work in their normal attitude and condition, without any special attention paid. The total amount of the recorded data is given in Table 7.

Data Records

The WEBA dataset is available at figshare[61], which can be assessed at https://doi.org/10.6084/m9.figshare.27186516.v3. The structure of the repository is shown in Fig. 9, with two main sub-folders for the baseline data and the work shift data, namely "A.participant_data" and "B.shift_data". The files are named and sorted similarly in the folder of every participant, and the folder of every shift as follows:

- Every folder "participant_X" within the "A.participant_data" folder contains the baseline data from the "X" participant, recorded on weekdays and weekends. The file "participant_summary" summarizes the collected information and medical history from all participants for easy comparison.
- Every folder "yyyymmdd_shift" within the "B.shift_data" folder contains the data collected from the morning or evening shift, in the day "dd", month "mm", the year "yyyy". The file "shift_summary" contains the general information of all shifts, such as the performed participant, start and end time of recording in each shift, objective measures such as number of drinks, and generated revenue. The file "orders_summary" summarizes

Folder name	File name	Format	Contained information
A_participant_data	participant_summary	csv	summary of physical condition and medical history of participants
participant_X (e.g., participant_1)	–	–	baseline data from one participant
	par_X_weekday	csv	HR baseline (bpm) * of the "X" participant in weekday, sampled at 135 Hz, raw data from Polar Verity sense.
	par_X_weekday	csv	HR baseline (bpm) of the "X" participant in weekday, sampled at 135 Hz, raw data from Polar Verity sense.
yyyymmdd_shift (e.g., 20231221_evening, 20231222_morning)	–	–	shift data by one participant
	1.body_acc	csv	3-axes body acceleration (m/s^2) during the shift, sampled at 25 Hz, calibrated by Sensor logger mobile application.
	2.hand_acc	csv	3-axes hand acceleration (m/s^2) during the shift, sampled at 12.5 Hz, raw and un-calibrated
	3.logs	txt	the timestamp of activity logs during the shift, raw timestamp from sensor
	4.hr	csv	the HR (bpm) of the participant during the shift, sampled at 135 Hz, raw data from Polar Verity sense.
	5.coffee_machine_acc	txt	3-axes coffee machine acceleration (m/s^2), raw and un-calibrated from sensor
	6.questionnaire	img	the subjective measure after the shift

Table 8. Data files and format in WEBA dataset. *: HR: Heart Rate; bpm: beat per minute.

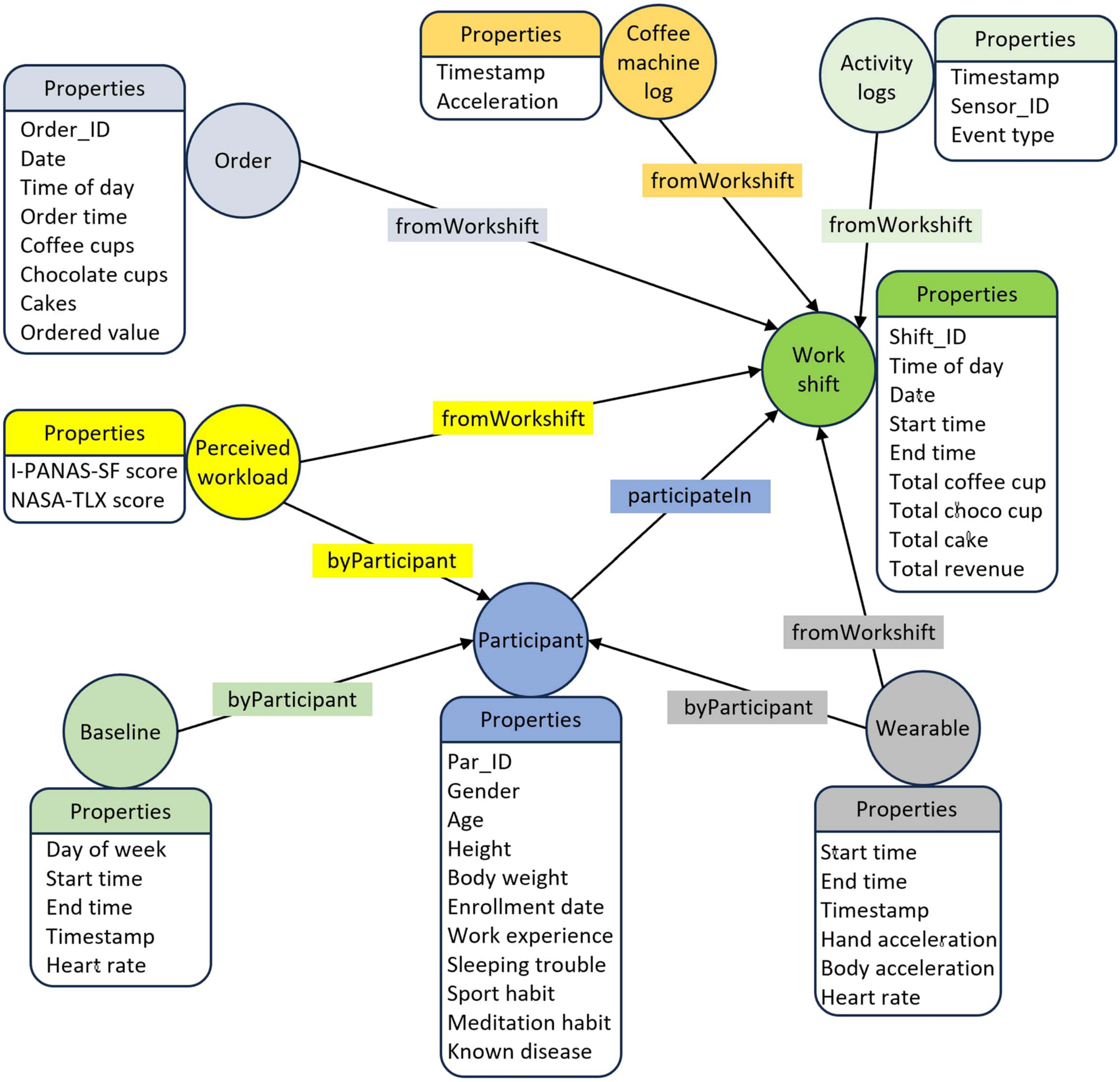

Fig. 10 The structure of linked data within the WEBA dataset. The data collected in each work shift can be traced by the unique ID number of the shift, the participated barista, and the received orders within that shift (namely "*shift_ID*", "*par_ID*", and "*order_ID*", respectively).

File	Variable	Description
participant_summary.xlsx	par_ID	Unique ID of a barista
	enroll_date	Enrollment date of the barista, in "dd/mm/yyyy" format
	gender	Gender: male or female
	age	Age of the barista in years old
	height	Height in centimeter
	body_weight	Body weight in kilogram
	work_experience	Experience of working in barista position, in month
	sleeping_troubles	Previous days of getting sleeping troubles
	sport_freq	Frequency of doing sport
	med_freq	Frequency of doing meditation
	known_disease	Other known disease
orders_summary.xlsx	order_ID	Unique ID of an order in POS system
	order_date	Date of receiving the order in "dd/mm/yyyy" format
	time_of_day	The shift of receiving the order, either be "morning" or "evening"
	order_time	The time of receiving the order, in "hh:mm:ss" AM/PM 12-hour format
	coffee_cup	The quantity of coffee-based drinks in the order.
	choco_cup	The quantity of chocolate-based drinks in the order.
	cake	The quantity of cakes in the order.
	ordered_value	The ordered amount. Currency in Hungarian forint (HUF).
shift_summary.xlsx	par_ID	ID of the barista who conducted the shift
	shift_ID	ID of the shift
	time_of_day	The time of the shift, either be "morning" or "evening"
	shift_date	The date of the shift, in "dd/mm/yyyy" format
	start_time	The starting time of the shift, in "hh:mm:ss" AM/PM 12-hour format
	end_time	The end time of the shift, in "hh:mm:ss" AM/PM 12-hour format
	total_coffee_cup	The quantity of coffee-based drinks that are made during the shift
	total_choco_cup	The quantity of chocolate-based drinks that are made during the shift
	total_cake	The quantity of cakes that are ordered during the shift
	total_revenue	The revenue during the shift, currency in Hungarian forint (HUF).
workload_summary.xlsx	par_ID	
	shift_ID	Unique ID of a shift
	elemental score of I-PANAS-SF	value within list of: upset; hostile; alert; ashamed; inspired; nervous; determined; attentive; active; afraid
	pos_score	I-PANAS-SF total positive score
	neg_score	I-PANAS-SF total negative score
	tally score of NASA-TLX	value within list of: mental.tw; physical.tw; temporal.tw; performance.tw; effort.tw; frustration.tw
	scaled score of NASA-TLX	value within list of: mental.sc; physical.sc; temporal.sc; performance.sc; effort.sc; frustration.sc
	weighted score of NASA-TLX	value within list of: mental.wc; physical.wc; temporal.wc; performance.wc; effort.wc; frustration.wc
	workload	overall workload score of NASA-TLX
logs.txt	front_door	TP-Link Tapo T110 sensor at the front door
	freezer	TP-Link Tapo T110 sensor at the door of the freezer
	l_door_cake_display; r_door_cake_display	TP-Link Tapo T110 sensor at the left and right door of the cake display
	l_wing_fridge; r_wing_fridge	TP-Link Tapo T110 sensor at the left and right door of the three-door fridge
	front_door_m	TP-Link Tapo T100 sensor at the front door
	zone_1; zone_2	TP-Link Tapo T100 sensor at the entrance of Zone 1 and Zone 2
	stair	TP-Link Tapo T100 sensor at the stair
	timestamp	Timestamp value of the recorded activity
	event_type	Type of events recorded by the TP-Link Tapo sensors, values within "Open/Close" with TP-Link Tapo T110, and only "Motion" with TP-Link Tapo T100

Table 9. Descriptions of variables used in the WEBA dataset.

the registered orders in the ordering system, with the ordered items, their quantity, and the ordered amount in money value. The file "workload_summary" summarizes the collected subjective measures from all shifts for easy comparison.

Details of these files and their format are given in Table 8. The structure of the linked data within the WEBA dataset is illustrated in Fig. 10. The description of each variable in the dataset is mentioned in Table 9.

Technical Validation

This dataset is unique in its setting, to show the effect of work content on emotions, performance, and workload perceptions of employees in real-life working conditions. All factors and possibly social interactions that are outside of work content were controlled or mitigated, thus the work content was the major stressor that the participants perceived. To our knowledge, there is no such a dataset with similar configuration, which was missing in the field of reflecting the work-content-related stress[21].

The baseline data of participants on weekdays and weekend was screened by medical experts from the Physiological Controls Research Center, Obuda University. It was confirmed that there was no abnormality in the HR data of each participant before they conducted the data collection during work shifts.

By the time of filling out the questionnaire at the end of every shift, the participants were asked again by the manager about the situation during the shift, to ensure that the measured shift was not significantly differed from their normal working day, and the perceived workload during that shift is truly what they judge from the actual requirement, not due to any other factors such as their temporary physical fitness or mental conditions. Only until then, the data of that shift was being recorded into the dataset, otherwise, it would have been discarded.

A limitation of our research is that we did not conduct a paper-based screening for the status of the participant at the beginning of every work shift, and this screening was only carried out through verbal communication with the field investigator. However, the data collected from shifts that were significantly affected by the emotional status, or personal physical problems of the participants were discarded at the end of the shift, when the participant confirmed that they were not in normal working status than usual.

Usage Notes

Noticeably with this dataset, besides the possibility of analyzing the effect of the work content on overall positive and negative scores of the I-PANAS-SF, the authors also encourage further granular analysis of the relationship between the work content and fine-grained emotions within the positive/negative group, thus discovering a more nuanced understanding of how work content may impact emotional status.

Code availability

Accessible along with the dataset without any restrictions, the program *preprocessing.py* compiled in Python language helps to read the dataset, extract the raw data from the activity logs, and sensor readings, and compile them into a dictionary for further analysis.

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Author contributions

T.T. conceptualized the problem, J.A. and T.R. shaped the research questions, supervised the work, and revised the manuscript. T.R. provided engineering advice, while GE contributed to the psychological aspect. T.T. carried out the data collection, analyzed the data, and wrote the first draft. All authors resolved the discrepancy and approved the final draft.

Competing interests

The authors declare no competing interests.

Additional information

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