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**PLAViMoP database: A new continuously assessed and collaborative 3D  
point-light display dataset**

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## **Abstract**

It was more than 45 years ago that Gunnar Johansson invented the point-light display technique. This showed for the first time that kinematics is crucial for action recognition, and that humans are very sensitive to their conspecifics' movements. As a result, many of today's researchers use point-light displays to better understand the mechanisms behind this recognition ability. In this paper, we propose PLAViMoP, a new database of 3D point-light displays representing everyday human actions (global and fine motor control movements), sports movements, facial expressions, interactions, and robotic movements. Access to the database is free, at <https://plavimop.prd.fr/en/motions>. Moreover, it incorporates a search engine to facilitate action retrieval. In this paper, we describe the construction, functioning, and assessment of the PLAViMoP database. Each sequence was analyzed according to four parameters: type of movement, movement label, sex of the actor, and age of the actor. We provide both the mean scores for each assessment of each point-light display, and the comparisons between the different categories of sequences. Our results are discussed in the light of the literature and the suitability of our stimuli for research and applications.

**Keywords:** biological movements; database; 3D motion capture; human movements, robotic movements, recognition test

## **Introduction**

Since the discovery of humans' ability to perceive, recognize and interpret human movements, several researchers have tried to identify the mechanism behind this ability (see Blake & Shiffrar, 2007; Decatoire et al., 2018; Pavlova, 2012, for a review). One very interesting methodology that consists in solely presenting kinematic information is point-light display (PLD), developed by Johansson (1973). In his groundbreaking experiment, this researcher asked observers to watch videos showing an actor performing an action. The actor was represented by point lights that indicated the motion of the actor's joints (head, shoulders, elbows, wrists, hips, knees and ankles). Despite the paucity of these stimuli, which showed neither the actor's body nor the context of the action, observers were able to recognize the represented action quickly and accurately. On the strength of these initial results, this paradigm has been extensively used over the past 40 years. It has shown that humans are not only capable of recognizing the actions that are performed, but can also perceive many characteristics of the actor, including his/her identity (Beardsworth & Buckner, 1981; Cutting & Kozlowski, 1977; Loula et al., 2005; Sevdalis & Keller, 2011; Troje et al., 2005; Westhoff & Troje, 2007), sex (Kozlowski & Cutting, 1977; Ma et al., 2006; Mather & Murdoch, 1994; Pollick et al., 2005; Runeson & Frykholm, 1983), emotional state (Atkinson et al., 2004; Chouchourelou et al., 2006; Clarke et al., 2005), and intentions (Chaminade et al., 2001; Martel et al., 2011; Runeson & Frykholm, 1983; Sevdalis & Keller, 2011). This is possible whether the sequences feature one or two actors (Manera et al., 2016; Okruszek & Chrustowicz, 2020). Using these very depleted stimuli, other studies have shown that humans can infer the characteristics of objects with which the actor interacts, such as weight (Runeson & Frykholm, 1981) and size (Jokisch & Troje, 2003).

This incredible ability appears to be related to the use of a specific brain network (Giese & Poggio, 2003) that includes not only brain areas involved in the visual perception of

movements, but also areas involved in the production and interpretation of actions (Urgesi, Candidi, & Avenanti, 2014), such as the mirror system, where several areas are activated at the same time when producing or observing actions (Cattaneo & Rizzolatti, 2009; Iacoboni & Mazziotta, 2007; Sale & Franceschini, 2012). Moreover, several authors have shown that the motor repertoire of observers influences the perceptual processing of PLDs: a rich motor repertoire acquired through practice enhances the perceptual processing (Bidet-Ildei et al., 2010; Chary et al., 2004; Louis-Dam et al., 1999; Pavlova et al., 2009), confirming the link between action production and action observation in PLDs (Ulloa & Pineda, 2007). Finally, many researchers have shown that PLDs can help researchers understand social (see Pavlova, 2012, for a review) and cognitive skills such as language (see Bidet-Ildei, Beauprez, et al., 2020, for a review) or number processing (Badets et al., 2015), and therefore constitute a valuable tool in the research community.

Despite the number of groups of researchers using PLDs across the world, few have tried to develop PLD databases that can be accessed by the community. Since 2004, to the best of our knowledge, ten databases have been made available to the community<sup>1</sup> and referred to indexed articles (see Table 1).

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<sup>1</sup> Some others databases are available in internet but they are not related to an indexed paper. You can consult for examples: <http://mocap.cs.cmu.edu/>, <http://www.jeroenvanboxtel.com/MocapDatabases.html>, <https://mocap.cs.sfu.ca/>, <https://mocap.web.th-koeln.de/>, <https://fling.seas.upenn.edu/~mocap/cgi-bin/Database.php>

Table 1: Main characteristics of PLD databases made available up to now referred to indexed articles

Name of the database	Reference	Type of movement and main characteristics of the database	Number of actors represented in display	Type of data	System of capture	Number of sequences
	Shipley & Brumberg, 2004)	Natural full-body human and animal movements (51 human and 28 animal)	1	2D coordinates and movie files	Filming actors with white reflective layers of tight	79
	Pollick et al., 2002	Natural full body human movements (knocking, waving and lifting) in both a neutral and angry styles	1	3D coordinates and movie files	Optotrack 3D system	1560
Action Database	Vanrie & Verfaillie, 2004	Natural full-body human movements (5 symmetrical, 16 implying a tool, 6 implying global motion, and 16 loopable) with 5 different points of view (frontal view (0°), two lateral views (facing left, 90°L, and facing right, 90°R); and the two three-quarter views in between (facing left, 45°L, and facing right, 45°R).	1	3D coordinates and movie files	Qualisys MacReflex motion-capture system	22
	Atkinson et al., 2004	Natural full-body emotional movements (happiness, sadness, fear, anger, and disgust) in three levels of exaggerations (typical, exaggerated and very exaggerated)	1	Movie files	A Sony DCR-VX2000E digital video camera filming actors with white reflective layers of tight	150
	Ma et al., 2006	Natural full-body human movements (walking, knocking, lifting, and throwing) in different emotional states (angry, happy, neutral, and sad).	1	3D coordinates	Falcon Analog optical motion capture system	4080

CID	Manera et al., 2010	Natural full-body communicative actions combining dyadic (9) and triadic (11) interactions with directive (18) and expressive (2) type of actions in 4 different viewpoints (90°, 125°, 270°, and 305°).	2 (two males or two females)	3D coordinates and movie files	Qualisys MacReflex motion capture system	20
	Zaini et al., 2013	43 communicative and 43 non communicative gestures (36 instrumental) and their scrambled equivalent	1	3D coordinates and movie files	Wireless Measurand ShapeWrap III Upper-body motion capture system	172
CID 5	Manera et al., 2016	Natural human full-body communicative (14 displays) and noncommunicative (7 displays) action. 13 implied an object and 14 are directive.	2 (two males or two females)	3D coordinates and movie files	Qualisys MacReflex motion capture system	21
	Lapenta et al., 2017	20 Biological and 40 scrambled full-body human actions	1	Movie files	JVC video camera (GR-D290u) mounted on a tripod filming actors with white reflective layers of tight	60
SoPID	Okruszek & Chrustowicz, 2020	Natural human full-body interactions including 12 neutral, gesture-based communicative interactions; 11 emotional exchanges (5 Happy /6 Angry), 6 synchronous interactive physical activity of actors, and 20 independent actions of agents (9 object-related, 11 non-object related) associated with a free tool which can modify the camera placement and projection, the size of markers, the appearance of PLD (with or without skeleton) and the spatial position of markers (scramble and flicker transformations).	1 or 2	3D coordinates and movie files.	OptiTrack motion tracking system	128

Here, we describe a new database (Point-Light Action Visualization and Modification Platform, PLAViMoP; <https://plavimop.prd.fr/en/motions>) featuring currently 177 human (whole body, upper body, face, with one or two agents) and 21 robotic 3D PLD sequences. The major advantages of this database are that it 1) brings together different types of stimuli (human, robotic) within a single tool, 2) includes a highly intuitive search engine that allows videos to be retrieved quickly and easily, 3) offers free downloads via the Internet and is scalable (anyone can upload a new PLD sequence), and 4) includes an online recognition test that can be performed by all visitors and provides a recognition rate for each PLD. This permit to facilitate the access to the movements of interest and to have a current idea of the recognition of each stimulus. Moreover, the presence of robotic movements is particularly interesting as control or to better understand the role of motor and/or visual system in the recognition of PLD. Each PLD sequence is accessible in two formats: MP4, to be directly used in experiments, and C3D, to be modified (see Decatoire et al., 2018, and <https://plavimop.prd.fr/en/software> for ways of making spatial and kinematic modifications).

After describing how the database was built, and how it works, we explain how we assessed it. We end by identifying its limitations but also its future prospects.

### **Database creation**

The PLAViMoP database contains both human and robotic PLD movements. All of these were captured using either the Qualisys MacReflex motion capture system (Qualisys; Gothenburg, Sweden) consisting of 16 Oqus 7+ cameras, or the Vicon motion capture system (VICON<sup>TM</sup> Inc., Denver, CO) composed of 20 MX-T40 cameras. Both systems' frame rates were set at 100 Hz. The resulting videos were then analyzed with Qualisys Track Manager

(QTM) or Nexus 1.8 to compute the 3D coordinates of reflective markers during the movements, and finally to build the corresponding PLD sequences<sup>2</sup>.

### ***Human movements***

#### *Global movements*

Two adults (one male and one female aged 20 years, with no motor, sensory or cognitive disorders) participated in the data collection. Each actor wore 33 reflective spherical markers measuring 14 mm in diameter (see Appendix 1 for detailed location), but after the reconstruction, each PLD only represented 19 points (see Appendix 1 for details). For each actor, we recorded 40 global movements: 31 representing everyday actions (e.g., walking, sitting down), and nine representing sporting gestures (e.g., golf swing, press-up). A full list of global movements is provided in Table 2.

#### *Fine-motor movements*

Two adults (one left-handed male aged 25 years and one right-handed female aged 38 years with no motor, sensory or cognitive disorders) participated in the data collection. Each actor wore nine reflective spherical markers measuring 6.4 mm in diameter and 38 reflective hemispherical auto-adhesive markers measuring 4 mm in diameter (see Appendix 2 for detailed locations). For each actor, we recorded 28 movements: 26 representing everyday actions (e.g., writing, drinking), and two representing experimental tasks (e.g., pointing with a tool). A full list of the fine-motor movements is provided in Table 3.

#### *Facial expressions*

We recruited two adults (one male aged 50 years and one female aged 30 years with no motor, sensory or cognitive disorders) who regularly acted in theaters. Each wore 41 markers: 38 4-mm hemispherical facial markers, and three 6.4-mm spherical markers for the sternum and

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<sup>2</sup> Since the writing of this paper some movements of a markerless motion capture system consisting of 4 Kinect azure DK cameras from Microsoft have been added. The frame rate of this system was lower as it was fixed at 30 Hz. The resulting videos were then analysed with iPiStudio-pro to calculate the 3D coordinates of the non-marker members, before being transformed into a PLD sequence with a MATLAB program. See <https://plavimop.prd.fr/en/motions> (judo and Goalkeeper dive).

shoulders (see Appendix 3 for details). Importantly, the position of the eyes was not directly recorded, but was calculated a posteriori from the position of dots placed at the outer canthus of each eye. This choice was made to render our PLDs more *face-like*, as a pretest including 15 adult participants showed that without eyes, our PLD faces seemed strange and ghostly. For each actor, 12 facial expressions were recorded (e.g., happiness, sadness). A full list of facial expressions is provided in Table 4.

### Interactions

Four actors (two for global interactions and two for facial interactions) participated. They were the actors we had recruited for the global movements and facial expressions. Using the same markers (i.e. for either global movements or facial expressions), we recorded 14 interactions: 10 global and 4 facial sequences. A full list of the interactions is provided in Table 5.

### **Robotic movements**

Robotic movements were recorded from the humanoid robot Nao (SoftBank Robotics; <https://www.ald.softbankrobotics.com>). We placed 25 markers measuring 6.4 mm in diameter on Nao (Appendix 4), and recorded 21 actions (for a full list, see Table 6).

### **Database functioning**

The PLAViMoP database comes in two parts: a search engine and a viewing window (see Fig. 1).

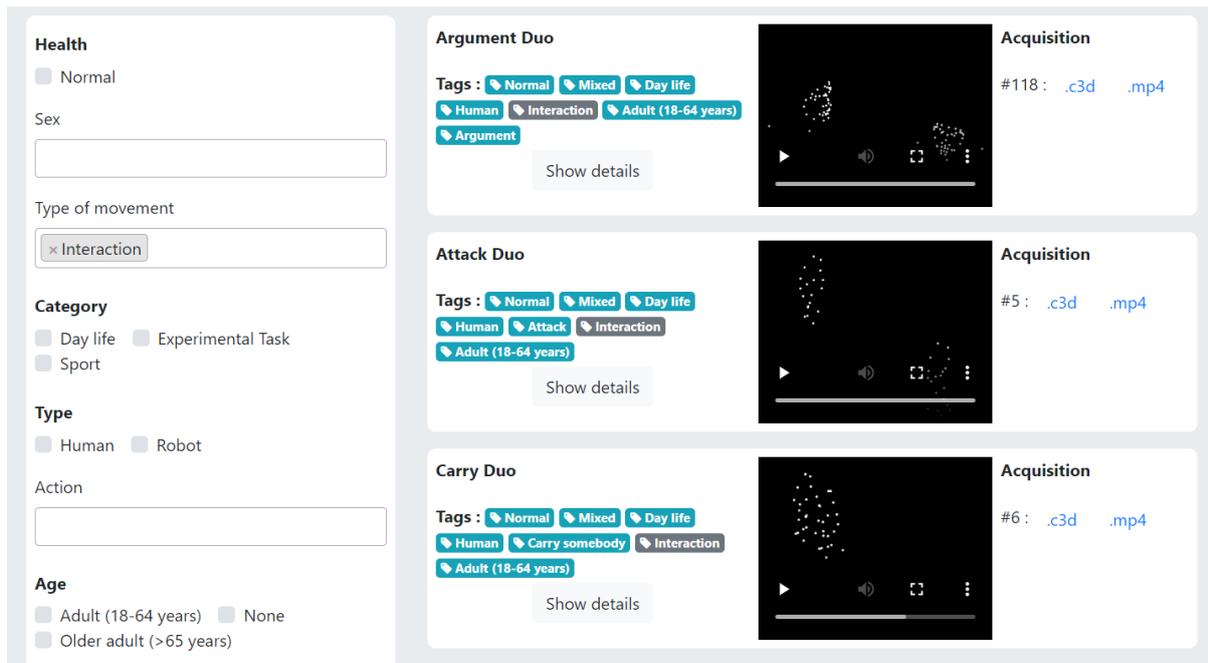


Figure 1: Overview of PLAViMoP database: search engine on the left and viewing window on the right.

The search engine makes it easy to retrieve PLDs in the dataset. Users can select several criteria (e.g., type of movement, sex, age). These criteria are programmed to evolve with the dataset development. For example, if a movement performed by a child is added to the dataset, *Children* will appear in the age category.

The viewing window displays the type of movement, the tags (e.g., sex, category, age), and an extract of each movement. All sequences can be downloaded in two formats: MP4, where the motion is seen from one choose viewpoint (an angle of  $45^\circ$  for the majority of displays), and C3D. C3D files contain the 3D coordinates of the motion, affording the possibility of constructing point-light versions of the actions seen from any desired perspective (Daems & Verfaillie, 1999; Olofsson et al., 1997; Verfaillie, 1993, 2000). With this format, it is also possible to add trajectories or modify the spatial and temporal parameters of the motion (for further details, see PLAViMoP software; <https://plavimop.prd.fr/en/software>, Decatoire et al.,

2018). Users can click on a “Show details” button to obtain details of how a given movement was captured and information about the recognition rate.

### **Database assessment**

The PLAViMoP platform was built to be scalable and autonomous. It includes an online recognition test that can be performed by all visitors. This recognition test lasts 5 minutes and consists of the recognition of five PLD sequences chosen randomly within the PLAViMoP database. Before starting the test, participants have to indicate their age, sex, and level of sporting activity. These data are stored anonymously. After the test, participants receive feedback about their recognition performance. Movement recognition data are updated as soon as a new person completes the recognition test. The results provided below are based on the data that were available for this online recognition test in June 2021.

### ***Participants***

703 participants ( $M_{\text{age}} = 25.6 \pm 10.5$  years; 59% women; 78% amateur athletes, 22% no sport practice) participated in the online recognition test.

### ***Stimuli***

The stimuli were extracted from the PLAViMoP database (see above for details of its construction).

### ***Procedure***

Participants each had to judge five PLD sequences extracted randomly from the PLAViMoP database. For each sequence, they had to indicate the sex of the actor (male, female, mixed, or none), the type of motion (human, animal, robotic), the label of the action (chosen from a list of 108 labels of the PLD sequences), and the age of the actor: adult (18-64 years), older adult (> 65 years), or child (none at present). No time limit was given to participants. Each sequence was played in a loop until the judgment was completed. At the end of the test, participants were given feedback about their performance (see Appendix 5).

## ***Results***

On 15 June 2021, we extracted all the results and divided them into five categories (global human movement, fine human movement, facial expression, interaction, and robotic movement). For each PLD sequence, we calculated the number of observers (male, female, total) who judged it, the mean age of these observers, and the percentages of observers who correctly recognized the type, label, sex, and age. As the evaluation method does not allow us to know precisely which displays were evaluated by the same person, we decided to carry out independent analyzes. Moreover, given the violation of normality, sphericity and/or homogeneity of values, it was difficult to find adequate statistical analysis. For us, the best statistical analyses were nonparametric tests. Mann-Whitney comparisons have been used for comparisons of sub-category in each category and Kruskal-Wallis test for the comparisons between categories. For all analyses, the effect size was given by the eta squared calculated with Psychometrica (Lenhard & Lenhard, 2016) and a calculation of the power was made a posteriori with gpower (Erdfelder et al., 1996).

### ***Human movements***

The results were analyzed separately according to action (global, fine, expression, interaction), and were then compared using a nonparametric Kruskal-Wallis test with action type (global, fine, expression, interaction) as a between-participants factor.

### **Global movements**

Results are set out in Table 2. On average, each PLD sequence was judged by 19 observers aged  $26 \pm 2$  years. The mean percentage of correct recognition responses was 62%, with 81% for type, 64% for label, 35% for sex, and 70% for age. The maximum label recognition score (100%) was achieved for “Walk Man”, “Walk Woman”, and “Walked aged Man”, and the minimum recognition score (0%) for “Volleyball Block Man”. Both daily life actions and

sports gestures are well recognized concerning the type of movement (Mean everyday actions= 77.6%, SD= 20.3%; Mean sport actions=91.27%, SD= 6.42%), the label of action (Mean everyday actions= 62.29%, SD= 25.05%; Mean sport actions=70.55%, SD= 26.49%) and the age of the actor (Mean everyday actions= 68.77%, SD= 17.15%; Mean sport actions=74.61%, SD= 16.80%). Concerning, the sex of the actor, the recognition is relatively low for both types of actions (Mean everyday actions= 34.43%, SD= 24.47%; Mean sport actions=35.89%, SD= 24.20%). Mann-Whitney comparisons indicated that there was no difference in the percentage of correct recognition responses between everyday actions and sport gestures, concerning label ( $U_{62,18} = 429, p = 0.13, \eta^2=0.02, 1-\beta= 0.18$ ), sex ( $U_{62,18} = 550, p = 0.94, \eta^2=0.001, 1-\beta= 0.05$ ), and age ( $U_{62,18} = 448, p = 0.21, \eta^2=0.01, 1-\beta= 0.11$ ). Concerning the type of movement, sport gestures were better recognized than everyday actions ( $U_{62,18} = 323, p < .01, \eta^2=0.07, 1-\beta= 0.53$ ).

### *Fine-motor movements*

Results are set out in Table 3. On average, each PLD sequence was judged by 16 observers aged  $25.2 \pm 2.4$  years. The mean percentage of correct recognition responses was 60%, with 87% for type, 52% for label, 23% for sex, and 78% for age. The maximum label recognition score (100%) was achieved for “Drink Woman” and “Light a Match Man”, and the minimum recognition score (0%) for “Sign Man”. Both daily-life actions and experimental tasks are well recognized concerning the type of movement (Mean daily life actions = 89.0%, SD = 14.6%; Mean experimental task = 73%, SD = 11.2%) and the age of the actor (Mean daily life actions= 79.5%, SD = 11.4%; Mean experimental task = 59.2%, SD = 7.89%) even in both cases Mann-Whitney comparisons indicate a better recognition for daily-life actions ( $U_{53,4} = 185, p <.05, \eta^2=0.11, 1-\beta= 0.26$  and  $U_{53,4} = 199, p <.01, \eta^2=0.15, 1-\beta= 0.36$  respectively). Concerning the recognition of the label of action (Mean daily life actions=

53.9%, SD = 29.2%; Mean experimental task=26%, SD = 15.8%) and the sex of the actor (Mean daily life actions= 24.0%, SD= 16.2%; Mean experimental task=23.0%, SD= 8.8%), they were relatively low for both subcategories with no difference between them even if we can observe a tendency to have a better recognition of label of action for daily-life than experimental task ( $U_{53,4} = 153, p = .07, \eta^2=0.04, 1-\beta= 0.12$  for the label of action and  $U_{53,4} = 96.5, p = .78, \eta^2=0.02, 1-\beta= 0.08$  for the sex of actor).

### Facial expressions

Results are set out in Table 4. On average, each PLD sequence was judged by 18 observers aged  $25.3 \pm 3.3$  years. The mean percentage of correct recognition responses was 50%, with 73% for type, 28% for label, 33% for sex, and 65% for age. The highest label recognition score (78%) was for “Laugh Man”, and the lowest recognition score (0%) was for “Doubt Woman and “Doubt Man”.

### Interactions

Results are set out in Table 5. On average, each PLD sequence was judged by 19 observers aged  $25.7 \pm 3$  years. The mean percentage of correct recognition responses was 71%, with 87% for type, 53% for label, 61% for sex, and 82% for age. The highest label recognition score (85%) was for “Dance Duo”, and the lowest recognition score (0%) was for “Tell a Joke Duo”. Both global and facial expressions are well recognized concerning the type of movement (Mean global= 93.5%, SD = 4.6%; Mean expression=72.8%, SD = 8.3%), the sex of the actor (Mean global= 59.7%, SD = 15.7%; Mean expression=65.2%, SD = 14.4%) and the age of the actor (Mean global= 85.3%, SD = 9.2%; Mean expression=76.8%, SD = 6.4%). Concerning the label of action, the recognition is lower for both subcategories (Mean global= 62.4%, SD = 26.1%; Mean expression=29.5%, SD = 31.8%). Mann-Whitney comparisons indicated that global and facial interactions did not differ on the percentage of correct recognition responses for label ( $U_{10,4} = 8, p = 0.10, \eta^2=0.21, 1-\beta= 0.36$ ), sex ( $U_{10,4} = 26, p =$

0.43,  $\eta^2=0.05$ ,  $1-\beta=0.12$ ), and age ( $U_{10,4}=9$ ,  $p=0.14$ ,  $\eta^2=0.17$ ,  $1-\beta=0.29$ ). Concerning type of movement, global interactions were better recognized than facial interactions ( $U_{10,4}=0$ ,  $p<.01$ ,  $\eta^2=0.57$ ,  $1-\beta=0.94$ ).

#### Effect of action type

Concerning the correct recognition of type of movement (see Fig. 3A), a Kruskal-Wallis test indicated a significant effect of action type ( $W_3=19.65$ ,  $p<.01$ ,  $\eta^2=0.09$ ,  $1-\beta=0.86$ ), with better recognition for fine-motor movement (mean = 87.8%,  $SD=19.1\%$ ) and interaction (mean = 87.6%,  $SD=11.2\%$ ) sequences than for global (mean = 80.7%,  $SD=18.9\%$ ) and facial expression (mean = 73%,  $SD=19.1\%$ ) sequences.

Concerning correct label recognition (see Fig. 3B), a Kruskal-Wallis test indicated an effect of action type ( $W_3=25.26$ ,  $p<.01$ ,  $\eta^2=0.13$ ,  $1-\beta=0.97$ ), with better recognition for global (mean = 64.1%,  $SD=25.1\%$ ) and interaction (mean = 53%,  $SD=30.7\%$ ) sequences than for fine (mean = 51.9%,  $SD=29.3\%$ ) and facial expression (mean = 29%,  $SD=26.9\%$ ) sequences.

Concerning correct recognition of sex (see Fig. 3C), a Kruskal-Wallis test indicated an effect of action type ( $W_3=27.19$ ,  $p<.01$ ,  $\eta^2=0.14$ ,  $1-\beta=0.98$ ), with better recognition for interaction (mean = 61.3%,  $SD=15\%$ ) sequences than for global (mean = 34.7%,  $SD=23.5\%$ ), facial expression (mean = 33.9%,  $SD=22.9\%$ ) and fine-motor (mean = 23.9%,  $SD=15.7\%$ ) sequences.

Concerning correct recognition of age (see Fig. 3D), a Kruskal-Wallis test indicated an effect of action type ( $W_3=20.7$ ,  $p<.01$ ,  $\eta^2=0.10$ ,  $1-\beta=0.90$ ), with better recognition for interaction (mean = 82.9%,  $SD=9.1\%$ ) and fine (mean = 78%,  $SD=912.3\%$ ) sequences than for global (mean = 70.08%,  $SD=17.9\%$ ) and facial expression (mean = 65.4%,  $SD=12.7\%$ ) sequences.

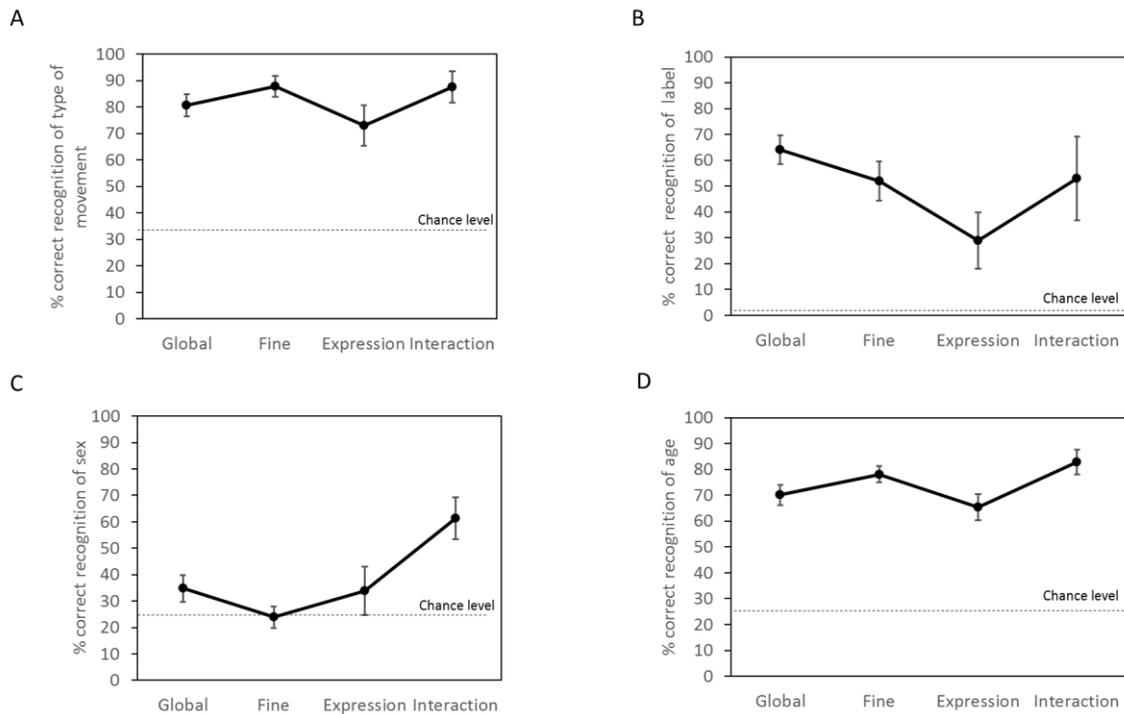


Figure 3: Mean results for the correct recognition of type of movement (A), label (B), sex (C), and age (D) for each type of human action (fine, expression, global, interaction). Error bars represent 95% confidence intervals. The horizontal dotted line represents chance level (33% for the type of movement, 0.92% for the label of action, 25% for the sex and the age of the actor).

### ***Robotic movements***

Results are set out in Table 6. Each PLD sequence was judged by 16 observers aged  $25 \pm 2.5$  years. The mean percentage of correct recognition responses was 56.4%, with 38% for type, 62.4% for label, 62.8% for sex and 62.8% for age. The best label recognition (92%) was for “Give Robot” and “Tai Chi Robot”, and the worst (4%) for “Clean Robot”.

### ***Effect of movement type***

We compared performances on human and robotic PLD sequences with a nonparametric Kruskal-Wallis test, with movement type (human, robotic) as a between-participants factor.

Concerning recognition of type of movement (see Fig. 4A), the Kruskal-Wallis test revealed a significant effect of action type ( $W_1 = 31.47, p < .01, \eta^2=0.16, 1-\beta= 0.99$ ), with better recognition for human sequences (mean = 82.5%,  $SD = 17.8\%$ ) than for robotic ones (mean = 38.2%,  $SD = 29.1\%$ ).

Concerning label recognition (see Fig. 4B), the Kruskal-Wallis test did not reveal any significant difference between human and robotic sequences ( $W_1 = 1.08, p = .30$ ).

Concerning recognition of the actor's sex (see Fig. 4C), the Kruskal-Wallis test indicated an effect of action type ( $W_1 = 24.7, p < .01, \eta^2=0.12, 1-\beta= 0.99$ ), with better recognition for robotic sequences (mean = 62.8%,  $SD = 19.3\%$ ) than for human ones (mean = 33.2%,  $SD = 22.6\%$ ).

Concerning recognition of the actor's age (see Fig. 4D), the Kruskal-Wallis test indicated an effect of action type ( $W_1 = 4.4, p < .05, \eta^2=0.02, 1-\beta= 0.5$ ), with better recognition for human sequences (mean = 73.08%,  $SD = 15.8\%$ ) than for robotic ones (mean = 62.2%,  $SD = 23.3\%$ ).

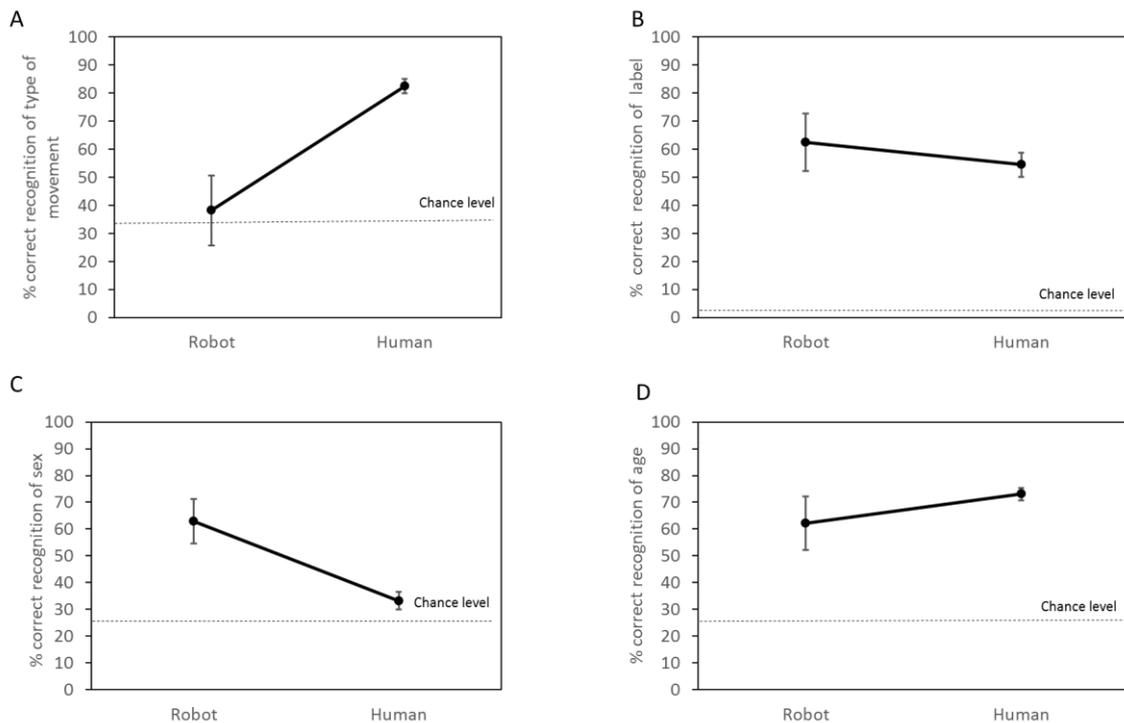


Figure 4: Mean results for the correct recognition of type of movement (A), label (B), sex (C) and age (D) according to movement type (human, robot). Error bars represent confidence intervals at 95%. The horizontal dotted line represents chance level.

## **Discussion**

In this paper, we describe the construction, functioning and assessment of the new PLAViMoP database, which currently contains 196 PLD sequences.—After discussing the results of the recognition test, we set out the limitations and perspectives.

First of all, our analysis showed that observers were able to correctly label the majority of our stimuli (mean action label recognition = 55%). Most importantly, the level of label recognition was above 70% for 71 PLD sequences (36 representing global human movements, 18 representing fine human movements, 3 representing facial expressions, 5 representing human interactions, and 9 representing robotic movements), indicating that they could be used without hesitation. Here, we discuss the results for human sequences, then for robotic sequences, and conclude by highlighting the usefulness of the PLAViMoP database for research and application.

### ***Recognition of human movements***

Mean label recognition for human PLD sequences was 54% (with a chance level at 0.92%)<sup>3</sup>, with better recognition for global and interaction movements than for fine movements and facial expressions. The level of correct label recognition for global and interaction sequences confirmed previous research highlighting a good ability to recognize these types of stimuli (Lapenta et al., 2017; Manera et al., 2010, 2016; Okruszek & Chrustowicz, 2020). Moreover it suggests that it is better for PLD sequences to show the whole body rather than just part of it (face or upper torso) (Atkinson et al., 2012). Concerning the weakness of facial expression

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<sup>3</sup> each label must be recognized among 108 possibilities

recognition observed in our study, this may be because we used not only prototypical facial expressions such as anger, happiness, disgust and surprise, but other facial expressions too, such as doubt and boredom. Prototypical facial expressions were fairly well recognized (> 57%), especially happiness (79.5%), in line with what is usually reported in the literature (Bidet-Ildei, Decatoire, et al., 2020; Leppänen & Hietanen, 2004). Concerning fine movements, the difficulty may have arisen from the labels we provided, which may have been too close to be distinctive (e.g., “write” vs. “sign” or “point” vs. “point with a tool”). However, to our knowledge, no study has previously studied the recognition of fine upper body movement, so we do not have any means of comparison.

Concerning recognition of the actor’s sex, we found relatively weak scores, with mean recognition of 38%, and only 34% for global human movements (see Pollick et al., 2005, for a comparison). These scores may be explained either by the 45° angle of our PLD sequences (Daems & Verfaillie, 1999) or by the ambiguity of the question. The choice of categories (*male, female, mixed, none*) may have encouraged some participants to answer “mixed” or “none” when they were not completely sure of their response. Recognition of the actor’s sex was particularly difficult for fine and facial expression sequences, in line with the idea that center of moment (Kozlowski & Cutting, 1977; Pollick et al., 2005), and more particularly the sway of the hips and shoulders (Lapenta et al., 2017; Mather & Murdoch, 1994), is crucial for this recognition.

Concerning recognition of type of movement and actor’s age, we obtained good results, with 82.5% correct recognition for type of movement and 73% for actor’s age. This suggests that adults can easily distinguish between human, robotic and animal movements, as well as between children, young adults and older ones. These abilities may be related to the level of activation of the motor network, which is known to be stronger for movements that belong to the individual’s motor repertoire (Calvo-Merino et al., 2005). However, our results need to be

confirmed, as we only had two types of movement (robotic and human) and two ages (young and older) for the moment in the database. Moreover, the database currently contains just one PLD sequence representing a movement performed by an older actor.

### ***Robotic movements***

Mean label recognition for robotic PLD movements was 62%, which is comparable to what we obtained for human movements. Interestingly, while observers more accurately judged human sequences in terms of type of movement and actor's age, judgements did not differ concerning label recognition, and were actually better for robotic sequences when it came to recognizing the actor's sex. As with humans, the weakness in recognizing the type of movement and the age of the actor in the robotic sequences can be explained by reduced activation of the motor network. This may also be in line with the fact that results were systematically more variable for robotic movements than for human ones. However, it is important to note that the ability to recognize the action label was equivalent for robotic and human sequences, suggesting that judgements of PLD sequences do not have to systematically rely on motor experience (Chaminade et al., 2001; Pavlova et al., 2009). This finding is consistent with the idea that motor representations can be built from visual experience, as has already been demonstrated in the literature (Beauprez et al., 2019; Beauprez et al., 2020). One other possibility is that the movements of the humanoid robot Nao can activate motor resonance (Agnew et al., 2007), insofar as its programs were inspired by human movements. Concerning observers' ability to recognize the sex of the actor in robotic PLD sequences, this can be explained simply by the lower level of ambiguity: if observers recognize a robotic action, there is therefore less ambiguity about their response concerning the sex of the actor (i.e., none).

### ***Limitations***

First, although the PLAViMoP database contains many different PLD sequences, there is currently no variability (only one repetition) for each proposed sequence. This could be problematic for protocols that require many repetitions of the same stimulus. However, as mentioned above, PLAViMoP is scalable, so several trials of the same action will probably be available in the future.

A second limitation is the a priori label chosen for each sequence. Some of these labels are currently too close (e.g., “write” vs. “sign” or “drink” vs. “drink from a bottle”) to be correctly classified. Consequently, in the majority of cases, actual recognition of the sequences was better than results suggest. It is important to bear in mind that the responses given by each observer for each sequence are accessible to everybody who is registered on the platform (consult “Show details” in viewing window). Consequently, we encourage researchers to regularly consult the latest available data and to access to individual responses.

Third, as the test is available on line, it is difficult to control the way it is performed (participant’ state, attention paid to test, reaction time, etc.). For this reason, it is important to have as large a number of responses as possible, and we encourage everybody to share the link to the recognition test (<https://plavimop.prd.fr/en/recognition>). Although the majority (136/197) of PLD sequences were judged by at least 15 participants in the present study, some were judged by only a few observers, and it will therefore be better to wait for more responses before using these.

Finally, we should be careful with our results because the procedure adopted in the recognition test does not allow to determine which display has been judged by the same participant. Consequently, the statistics realized cannot be purely dependent or independent. In the present experiment, we decided to use independent statistics, but future research should control which display is associated to each participant. Moreover, the analysis of effect size and power sometimes displayed weak or moderate effects. Consequently, future analyses of

the stimuli included on PLAViMoP database could be carried out with classical experimental procedures to better control the different parameters of analysis and to predict a priori both the number of stimuli and participants to have significant effects at  $p < .05$  and a power of 0.80.

### ***Conclusion and perspectives***

Despite these limitations, we think that PLAViMoP database could be a very useful tool for working with PLD sequences. Accessible to everybody, it allows large numbers of human and robotic PLD sequences to be retrieved quickly and easily. The presence of robotic movements could be potentially very interesting for researchers in psychology to be used as control for biological motions or for researchers in robotics to better understand how humans can perceive and judge robotic actions. Moreover, the choice of format (MP4 or C3D) means that they can either be used directly for practice or can be spatially and/or kinematically modified (e.g., by adding masking dots or scrambling the action; see Decatoire et al., 2019, and <https://plavimop.prd.fr/en/software> for possible transformations). The PLAViMoP database could therefore be useful for researchers, by allowing them to directly access normative PLD stimuli to study perceptual, motor, cognitive and/or social issues. Moreover, PLAViMoP could make PLDs more accessible to practitioners for use in sport or rehabilitation. Many studies have shown that action observation can improve performance in sports (see for example Faelli et al., 2019 and Francisco et al., 2022 for recent studies), as well as motor (see Ryan et al., 2021; Sarasso et al., 2015 for reviews) and cognitive (see Marangolo & Caltagirone, 2014, for a review) abilities, but it has seldom been used until now, mainly because accessing stimuli is difficult.

In conclusion, PLAViMoP constitutes a useful tool for researchers and practitioners that can work with PLD stimuli. Moreover, the collaborative and scalable options could lead to

interesting opportunities in the future. Concerning the perspectives, we are working to develop the database by adding more specialist sports movements (e.g., judo, soccer) and movements performed by individuals with motor and/or cognitive disabilities. Moreover, we aim to add several sequences for each action, in order to add some variability.

### Open practices Statements

The data and materials presented in this paper are available online at:  
<https://plavimop.prd.fr/en/motions>

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Table 2: Data for the assessment of global PLD sequences.

Action label	<i>N</i> women	<i>N</i> men	<i>N</i> observers	Mean age of observers	% correct type recognition	% correct label recognition	% correct sex recognition	% correct age recognition
<b>Action category: Daily-life</b>								
Acquiesce Man	11	11	22	26	73	55	41	45
Acquiesce Woman	9	8	17	25	24	12	82	65
Applaud Man	13	8	21	25	76	90	29	48
Applaud Woman	15	8	23	25	78	96	4	74
Catch Man	9	7	16	24	69	13	50	63
Catch Woman	13	4	17	24	88	53	24	71
Crawl Man	22	6	28	26	54	79	18	36
Crawl Woman	14	8	22	28	64	73	0	45
Cross Oneself Man	10	5	15	32	93	80	33	80
Cross Oneself Woman	14	14	28	26	82	57	18	79
Crouch Man	11	2	13	28	92	46	23	92
Crouch Woman	10	10	20	30	80	80	35	85
Decline Man	10	3	13	27	38	8	38	38
Decline Woman	12	7	19	27	63	5	11	74
Fall Man	15	6	21	22	95	95	43	57
Fall Woman	14	5	19	21	79	95	11	32
French Military Salute Man	12	7	19	25	84	53	42	63
French Military Salute Woman	11	12	23	28	78	30	22	78
Hop Man	5	5	10	27	90	70	70	60
Hop Woman	7	7	14	23	14	71	79	93
Jump Man	19	5	24	24	58	54	25	33
Jump Woman	9	6	15	28	20	87	67	60
Ladder Climb Man	13	8	21	26	95	67	71	67
Ladder Climb Woman	14	8	22	28	86	86	18	77
Ladder Get Off Man	13	3	16	23	88	88	44	88
Ladder Get Off Woman	11	9	20	27	95	80	15	85
Move Back Man	12	10	22	26	64	55	50	59
Move Back Woman	10	11	21	28	62	57	14	48
Pick Up Man	8	4	12	27	92	42	17	75
Pick Up Woman	11	9	20	26	80	55	30	75
Pull Man	9	4	13	23	100	69	62	62
Pull Woman	6	9	15	24	93	60	7	80
Push Somebody Man	11	7	18	27	100	67	44	94

Push Somebody Woman	13	3	16	24	69	25	6	63
Put Down Man	10	10	20	27	100	45	45	95
Put Down Woma	5	7	12	34	92	75	8	83
Salute Woman	9	3	12	28	92	33	92	67
Say Hello Man	8	13	21	24	95	33	24	76
Say Hello Woman	21	8	29	26	83	31	31	66
Scratch Man	15	5	20	32	75	60	45	75
Scratch Woman	10	10	20	23	85	30	5	75
Sit Man	8	8	16	26	75	63	19	81
Sit Woman	10	9	19	26	84	63	16	84
Skip Man	10	5	15	25	100	60	47	73
Skip Woman	14	7	21	23	95	81	29	29
Stand Man	13	13	26	22	50	69	73	96
Stand Man	8	4	12	21	92	92	17	92
Step Climb Man	10	11	21	27	95	86	57	81
Step Climb Woman	12	6	18	22	94	94	11	89
Step Get Off Man	9	2	11	24	45	36	82	45
Step Get Off Woman	8	9	17	23	94	24	12	82
Sweep Man	9	6	15	29	40	33	20	27
Sweep Woman	11	9	20	28	65	75	25	55
Tiptoes Walk Man	10	4	14	23	93	50	57	71
Tiptoes Walk Woman	3	10	13	27	77	69	8	62
Turn Man	13	8	21	27	81	81	19	76
Turn Woman	16	8	24	24	96	92	29	83
Twist Man	11	5	16	23	94	75	50	100
Twist Woman	19	10	29	27	59	59	17	66
Walk Older Man	4	3	7	23	71	100	71	43
Walk Man	10	6	16	31	81	100	69	69
Walk Woman	10	4	14	24	93	100	14	79
<b>Action category: Sport</b>								
Golf Swing Man	8	5	13	35	100	85	77	100
Karate Kick Woman	12	6	18	28	89	44	6	89
Karate Punch Woman	15	7	22	28	91	95	14	95
Kick Man	14	9	23	25	96	65	48	87
Kick Woman	11	5	16	24	88	81	13	44
Pedal Man	14	8	22	28	95	91	45	86
Pedal Woman	11	6	17	27	76	94	12	53
Pump Man	11	10	21	26	95	90	81	81

Pump Woman	20	4	24	26	83	83	8	58
Run Man	10	4	14	28	100	86	64	86
Run Woman	13	12	25	26	92	96	16	88
Shoot Man	14	11	25	23	92	40	48	76
Shoot Woman	10	9	19	27	89	58	11	47
Throw Man	7	5	12	23	92	33	42	83
Throw Woman	13	9	22	28	82	82	27	64
Twisted Back Somersault Man	15	12	27	27	89	85	37	70
Volleyball Block Man	9	8	17	24	94	0	35	59
Volleyball Smash Man	3	10	13	28	100	62	62	77

Table 3: Data for the assessment of fine PLD sequences.

Action label	<i>N</i> women	<i>N</i> men	<i>N</i> observers	Mean age of observers	% correct type recognition	% correct label recognition	% correct sex recognition	% correct age recognition
<b>Action category: Daily-life</b>								
Bounce a Ball Man	10	6	16	22	100	69	38	88
Bounce a Ball Woman	15	7	22	29	82	50	23	82
Brush One's Teeth Woman	7	8	15	24	87	67	20	80
Call Man	9	10	19	25	89	89	16	89
Call Woman	12	8	20	26	25	90	90	80
Close a Bottle Woman	9	5	14	27	93	50	21	79
Close a Pot Man	6	7	13	24	100	31	8	92
Close a Pot Woman	10	6	16	21	94	25	19	88
Count Man	5	3	8	30	100	50	25	88
Count Woman	13	3	16	23	100	94	31	75
Cut With a Knife Man	6	6	12	25	83	75	17	83
Cut With a Knife Woman	16	6	22	24	95	18	14	77
Draw Man	15	6	21	28	86	67	29	57
Draw Woman	9	4	13	26	85	46	8	77
Drink From a Bottle Man	7	9	16	30	88	25	19	81
Drink From a Bottle Woman	10	6	16	22	81	19	6	81
Drink Man	10	6	16	27	75	75	25	75
Drink Woman	8	11	19	26	100	100	26	79
Eat Man	7	10	17	25	76	82	12	82
Eat Woman	11	10	21	27	95	81	14	71
Juggle Man	8	6	14	28	86	93	7	50
Light a Match Man	7	6	13	29	92	100	31	69
Light a Match Woman	13	12	25	25	80	96	8	72
Make Up Man	12	16	28	28	89	14	25	86
Make Up Woman	8	6	14	26	93	43	36	93
Nail Man	5	4	9	20	89	22	11	33
Nail Woman	9	11	20	24	100	20	25	85
Open a Bottle Man	12	6	18	25	89	44	17	72
Open a Bottle Woman	7	7	14	22	100	57	21	86
Open a ot Man	9	5	14	26	100	50	36	100

Open a pot Woman	8	9	17	24	100	71	29	76
Open and Close a Box Man	7	8	15	24	100	7	20	87
Open and Close a Box Woman	11	6	17	27	100	6	18	82
Paint Man	6	5	11	24	91	9	9	73
Paint Woman	12	5	17	25	94	29	18	82
Pour Man	10	7	17	26	88	59	29	82
Pour Woman	14	3	17	26	88	82	35	82
Screw Man	9	7	16	32	88	31	25	63
Screw Woman	14	10	24	23	96	42	8	83
Sign Man	6	6	12	25	92	0	25	100
Sign Woman	5	4	9	26	22	44	89	78
Tape Man	7	6	13	22	100	62	23	85
Tape Woman	13	6	19	21	89	32	32	84
Throw and Catch a Ball Man	10	7	17	24	82	65	29	82
Type on Keyboard Man	12	9	21	27	90	90	19	86
Type on keyboard Woman	12	5	17	30	100	88	24	88
Unscrew Man	12	8	20	23	90	10	35	85
Unscrew Woman	7	7	14	26	93	29	0	86
Wipe Man	11	8	19	25	95	37	26	79
Wipe Woman	6	10	16	26	94	69	38	88
Write Man	14	7	21	28	90	86	19	81
Write SMS Woman	8	6	14	24	93	79	36	57
Write Woman	10	6	16	23	88	88	6	75
<b>Action category: Experimental task</b>								
Point Man	11	8	19	27	89	21	26	63
Point with a Tool Man	7	7	14	22	64	7	21	50
Point with a Tool Woman	5	4	9	25	67	44	33	56
Point Woman	11	14	25	25	72	32	12	68

Table 4: Data for the assessment of facial expression PLD sequences.

Action label	<i>N</i> women	<i>N</i> men	<i>N</i> observers	Mean age of observers	% correct type recognition	% correct label recognition	% correct sex recognition	% correct age recognition
Anger Man	7	4	11	32	91	64	64	82
Anger Woman	11	6	17	21	82	59	35	71
Boredom Man	12	6	18	28	78	11	44	50
Boredom Woman	7	5	12	21	0	17	67	58
Disapointment Man	11	9	20	25	85	5	45	75
Disapointment Woman	9	15	24	29	75	25	25	50
Disgust Man	9	8	17	22	71	29	41	65
Disgust Woman	13	12	25	23	60	16	16	64
Doubt Man	14	7	21	26	76	0	33	71
Doubt Woman	7	7	14	24	71	0	7	86
Fear Man	11	4	15	22	93	7	60	87
Fear Woman	9	12	21	21	67	5	10	62
Joy Man	11	6	17	25	71	47	65	65
Joy Woman	14	6	20	24	65	10	5	60
Laugh Man	8	8	16	21	94	81	44	88
Laugh Woman	16	7	23	24	78	78	13	48
Neutral Face Man	9	6	15	29	73	27	47	53
Neutral Face Woman	8	6	14	24	57	43	0	43
Pain Man	10	3	13	32	92	8	77	77
Pain Woman	14	11	25	27	72	0	12	64
Sadness Man	9	10	19	27	79	21	42	53
Sadness Woman	12	8	20	29	70	10	0	60
Surprise Man	11	6	17	24	94	59	41	71
Surprise Woman	10	9	19	29	58	74	21	68

Table 5: Data for the assessment of interaction PLD sequences.

Action label	<i>n</i> women	<i>n</i> men	<i>N</i> observers	Mean age of observers	% correct type recognition	% correct label recognition	% correct sex recognition	% correct age recognition
<b>Action category: Facial</b>								
Argument Duo	7	9	16	23	81	56	69	81
Conversation Duo	12	7	19	24	63	58	74	74
Sweet Words Duo	13	10	23	26	78	4	74	83
Tell a Joke Duo	8	8	16	25	69	0	44	69
<b>Action category: Global</b>								
Attack Duo	11	14	25	24	92	16	36	92
Carry Duo	7	9	16	27	94	88	56	81
Cuddle Duo	7	2	9	25	100	78	56	100
Dance Duo	6	7	13	34	85	92	85	77
Handshake Duo	11	7	18	25	100	78	39	94
High Five Duo	10	8	18	30	89	83	56	72
Kiss Duo	12	8	20	24	95	65	65	90
Pass Duo	11	12	23	25	96	35	65	74
Shake Duo	21	9	30	25	93	53	57	87
Show Duo	15	7	22	27	91	36	82	86

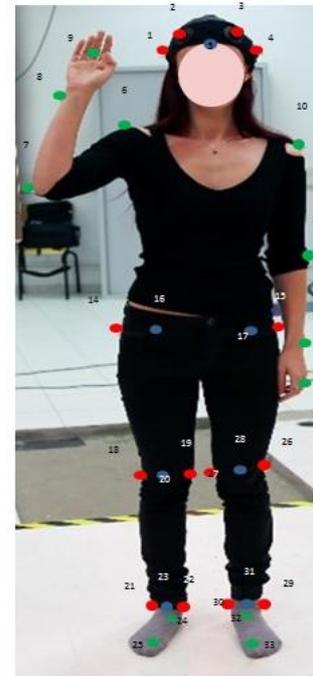
Table 6: Data for the assessment of robotic PLD sequences.

Action label	<i>N</i> women	<i>N</i> men	<i>N</i> observers	Mean age of observers	% correct type recognition	% correct label recognition	% correct sex recognition	% correct age recognition
Acquiesce Robot	12	3	15	26	27	73	67	67
Air Guitar Robot	4	8	12	27	33	50	58	50
Applaud Robot	9	7	16	31	75	63	44	63
Caress Robot	7	2	9	21	44	56	33	33
Clean Robot	16	8	24	27	50	4	63	67
Crouch Robot	11	3	14	25	43	64	64	57
Dance Robot	11	5	16	26	56	63	56	63
Drink Robot	11	6	17	23	41	41	41	35
Give Robot	5	7	12	26	17	92	92	92
Juggle Robot	16	6	22	23	36	45	45	73
Move Back Robot	8	9	17	22	35	65	82	82
Pick Up Robot	8	11	19	24	5	84	74	68
Salute Robot	12	6	18	28	17	78	67	72
Say Hello Robot	10	7	17	26	12	76	76	65
Scratch Eye Robot	10	5	15	22	100	73	87	0
Scratch Hand Robot	10	12	22	27	0	59	64	68
Scratch Torso Robot	14	7	21	25	10	10	24	24
Show Robot	7	3	10	23	30	50	40	60
Tai Chi Robot	9	3	12	24	0	92	92	92
Turn Robot	17	7	24	22	79	88	71	88
Walk Robot	8	7	15	28	93	87	80	87

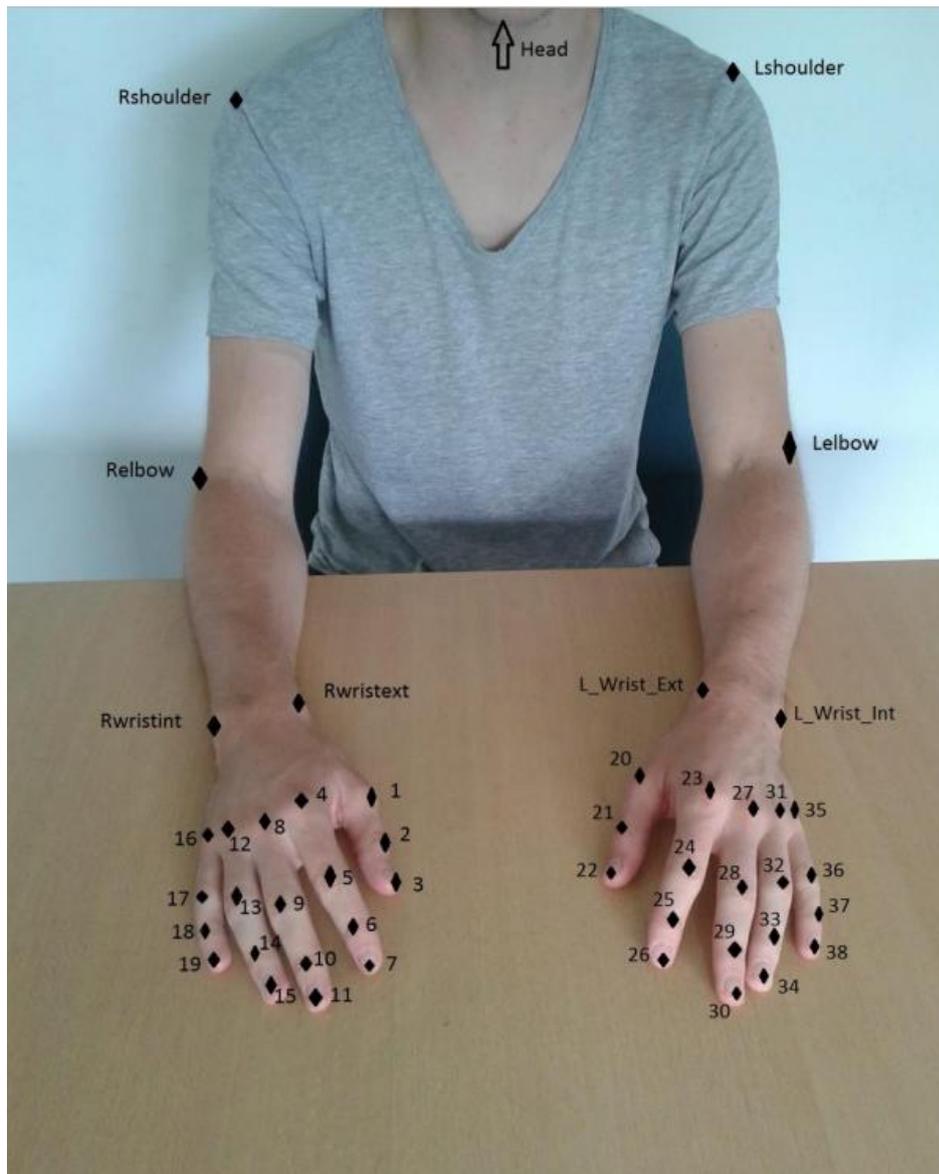
## Appendices

### Appendix 1: Position of markers for global and global interaction movements

N°	Types	Labels	Localisations
1	Real marker not kept in C3D file	None	Right back head
2	Real marker not kept in C3D file	None	Right front head
3	Real marker not kept in C3D file	None	Left front head
4	Real marker not kept in C3D file	None	Left back head
5	Virtual marker computed and add in C3D file	Head	Computed as the middle of markers 1, 2, 3 & 4
6	Real marker still in C3D file	R_Shoulder	Right acromion
7	Real marker still in C3D file	R_Elbow	Right lateral epicondyle
8	Real marker still in C3D file	R_Wrist	Right radial styloid
9	Real marker still in C3D file	R_Finger	Proximal phalanx of the right middle finger
10	Real marker still in C3D file	L_Shoulder	Left acromion
11	Real marker still in C3D file	L_Elbow	Left lateralepicondyle
12	Real marker still in C3D file	L_Wrist	Left radial styloid
13	Real marker still in C3D file	L_Finger	Proximal phalanx of the left middle finger
14	Real marker not kept in C3D file	None	Right greater trochanter
15	Real marker not kept in C3D file	None	Left greater trochanter
16	Virtual marker computed and add in C3D file	R_Hip	Computed as described in Weinhandl JT, O'Connor KM. Assessment of a greater trochanter-based method of locating the hip joint center. J Biomech 2010; 43: 2633–2636
17	Virtual marker computed and add in C3D file	L_Hip	
18	Real marker not kept in C3D file	None	Right lateral tibial condyle
19	Real marker not kept in C3D file	None	Right medial tibial condyle
20	Virtual marker computed and add in C3D file	R_Knee	Computed as the middle of markers 18 & 19
21	Real marker not kept in C3D file	None	Right lateral malleolus
22	Real marker not kept in C3D file	None	Right medial malleolus
23	Virtual marker computed and add in C3D file	R_Ankle	Computed as the middle of markers 21 & 22
24	Real marker still in C3D file	R_Heel	Right heel
25	Real marker still in C3D file	R_Toe	Right toe
26	Real marker not kept in C3D file	None	Left lateral tibial condyle
27	Real marker not kept in C3D file	None	Left medial tibial condyle
28	Virtual marker computed and add in C3D file	L_Knee	Computed as the middle of markers 26 & 27
29	Real marker not kept in C3D file	None	Left lateral malleolus
30	Real marker not kept in C3D file	None	Left medial malleolus
31	Virtual marker computed and add in C3D file	L_Ankle	Computed as the middle of markers 29 & 30
32	Real marker still in C3D file	L_Heel	Left heel
33	Real marker still in C3D file	L_Toe	Left toe



## Appendix 2: Position of markers for fine-motor movements



47 markers:

- 9 on the body: Head, R\_Shoulder, L\_Shoulder, R\_Elbow, L\_Elbow, R\_Wrist\_Int, R\_Wrist\_Ext, L\_Wrist\_Int, L\_Wrist\_Ext

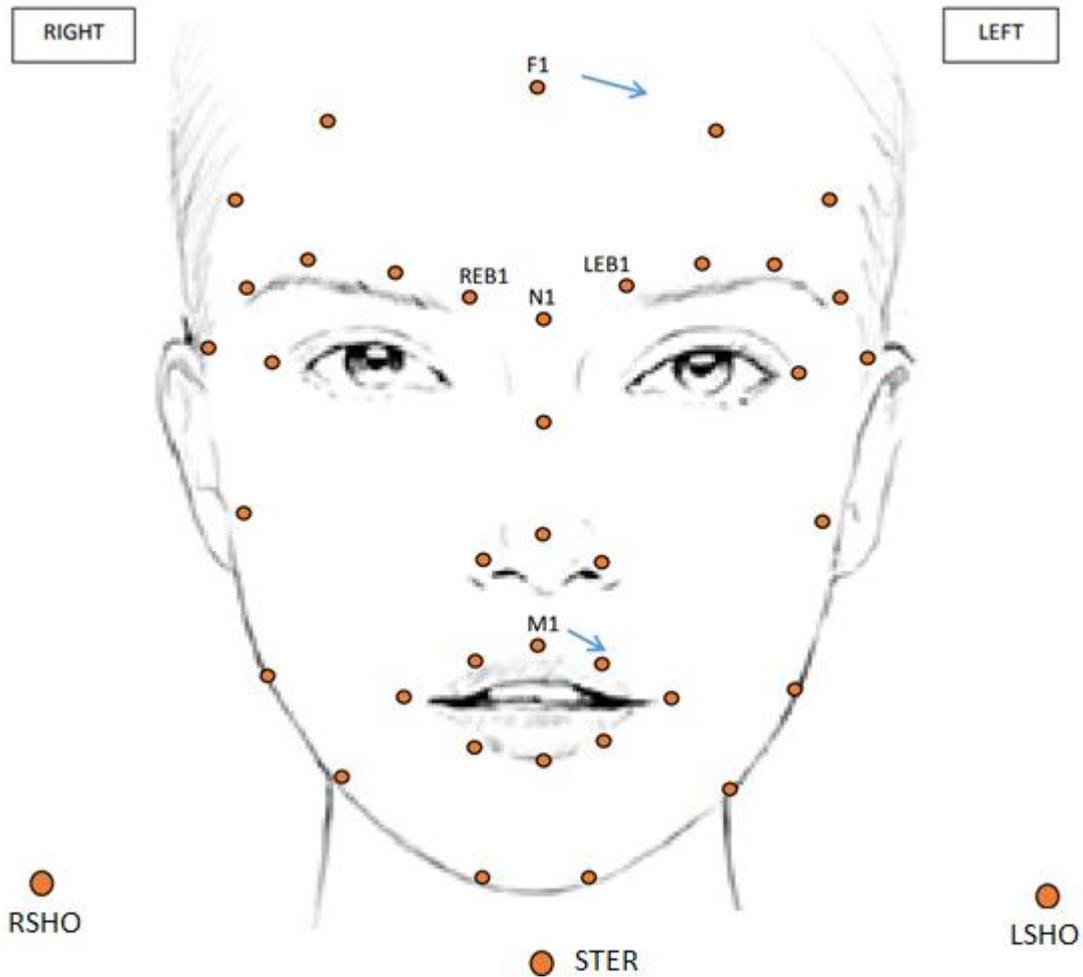
19 on the right hand

1 : R_MC1	8 : R_MC3	15 : R_D4
2 : R_M1	9 : R_P3	16 : R_MC5
3 : R_D1	10 : R_M3	17 : R_P5
4 : R_MC2	11 : R_D3	18 : R_M5
5 : R_P2	12 : R_MC4	19 : R_D5
6 : R_M2	13 : R_P4	
7 : R_D2	14 : R_M4	

19 on the left hand

20 : L_MC1	27 : L_MC3	34 : L_D4
21 : L_M1	28 : L_P3	35 : L_MC5
22 : L_D1	29 : L_M3	36 : L_P5
23 : L_MC2	30 : L_D3	37 : L_M5
24 : L_P2	31 : L_MC4	38 : L_D5
25 : L_M2	32 : L_P4	
26 : L_D2	33 : L_M4	

Appendix 3: Position of markers for facial expressions and facial interactions



41 markers:

8 on eyebrows: REB1 / REB2 / REB3 / REB4 / LEB1 / LEB2 / LEB3 / LEB4

2 on eyes: ER / EL 5

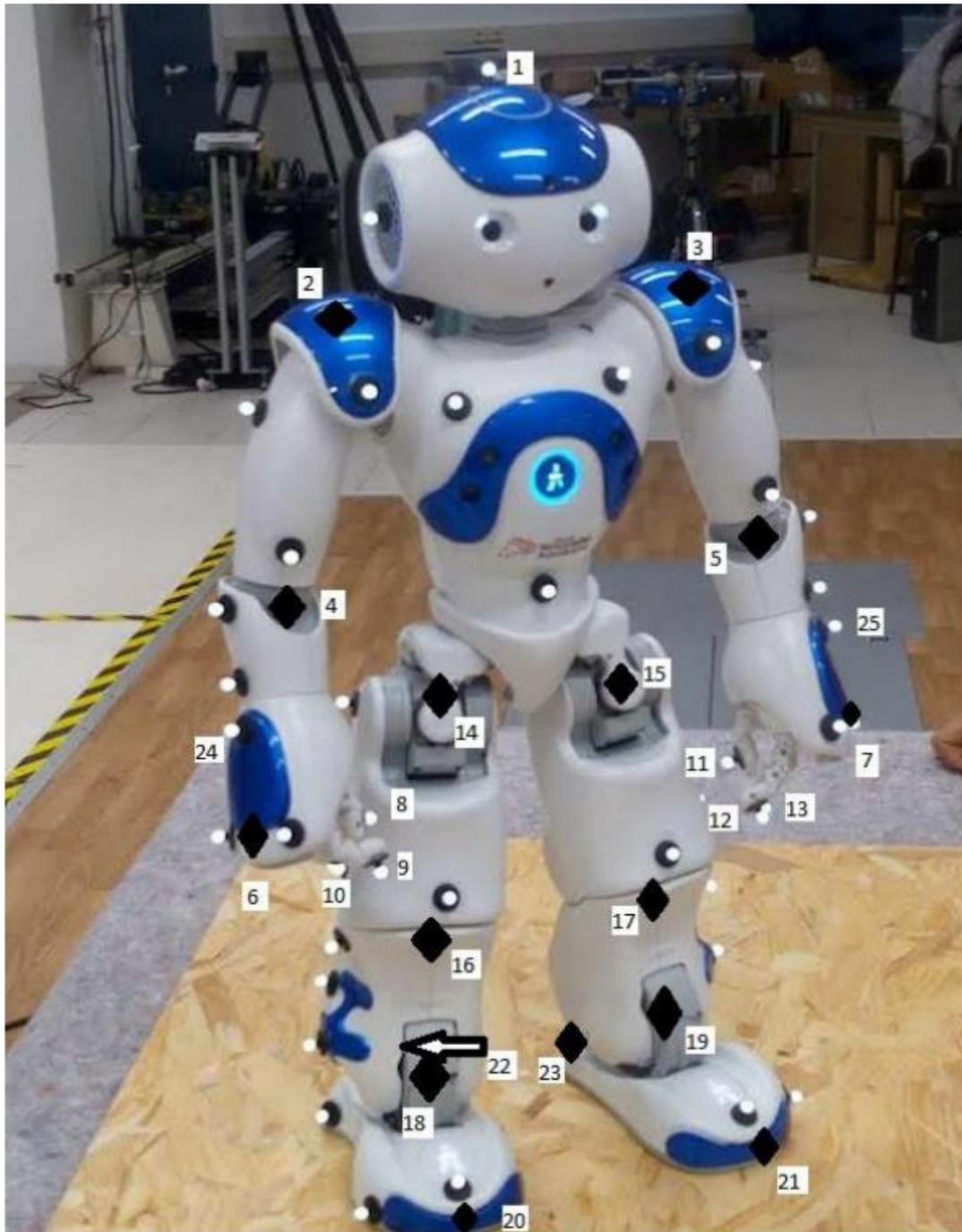
5 on nose: N1 / N2 / N3 / NR / NL

8 on mouth: M1 / M2 / M3 / M4 / M5 / M6 / M7 / M8

15 on face: F1 / F2 / F3 / F4 / F5 / F6 / F7 / F8 / F9 / F10 / F11 / F12 / F13 / F14 / F15

+ RSHO, LSHO, STER

#### Appendix 4: Position of markers for robotic movements



25 Markers : 1 Top\_Head 6 Right\_Finger 11 Left\_Finger\_1 16 Right\_Knee 21 Left\_Toe 2 Right\_Shoulder 7 Left\_Finger 12 Left\_Finger\_2 17 Left\_Knee 22 Right\_Heel (Non visible) 3 Left\_Shoulder 8 Right\_Finger\_1 13 Left\_Finger\_3 18 Right\_Ankle 23 Left\_Heel 4 Right\_Elbow 9 Right\_Finger\_2 14 Right\_Hip 19 Left\_Ankle 24 Right\_Wrist 5 Left\_Elbow 10 Right\_Finger\_3 15 Left\_Hip 20 Right\_Toe 25 Left\_Wrist.

Appendix 5: Procedure for the online test. 1) The participant was informed about the test. 2) He/she had to provide personal information, 3) He/she judged five PLD sequences (see one example shown below), and 4) He/she was given feedback. A mean recognition rate was given, and for each PLD sequence, correct responses were shown in green, and incorrect ones in red (see two examples shown below).

1/7

Here, you can respond to a quick survey (5 minutes max) for some of the PLDs available in the Database. For each PLD, you will have to mention, the sex and age of the participant, the type of action (start to type the first letters in the drop down menu) and the type of movement.

Before the survey, information about you and your sensory motor expertise is requested. These data are conserved anonymously.

You will receive feedback following the survey, and the percentage of participants who recognize the characteristics of the PLD is provided for each PLD in the Database.

Thank you for your collaboration.

2/7

**recognition\_test.step2\_title**

**Gender**

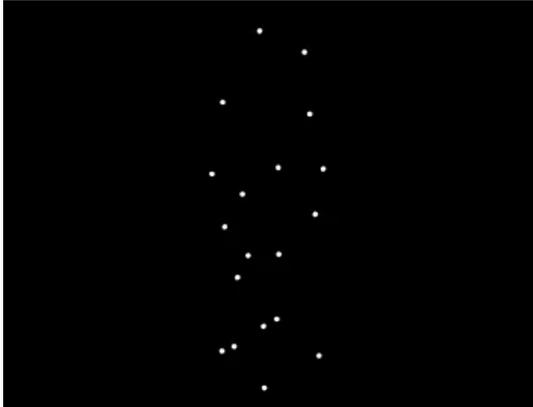
Male  Female

Age

Sensory motor expertise

>

## Recognition #2



## Sex

Female(s)  Male(s)  Mixed  None

## Type

Animal  Human  Robot

## Action

---

## Age

Adult (18-64 years)  Children  None  
 Older adult (>65 years)



## Thank for your participation

Recognition rate : 95 %

## #4 Applaud Woman



## Associated tags :

Health

Normal

Sex

Female(s)

Type of movement

Global

Category

Day life

Type

Human

Action

Applaud

Age

Adult (18-64 years)

## Your choices :

Sex

Female(s)

Type

Human

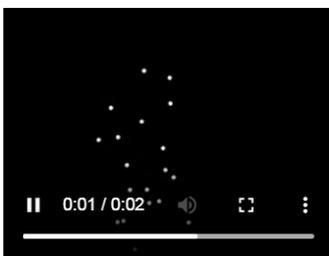
Action

Applaud

Age

Adult (18-64 years)

## #7 Catch Man



## Associated tags :

Health

Normal

Sex

Male(s)

Type of movement

Global

Category

Day life

Type

Human

Action

Catch

Age

Adult (18-64 years)

## Your choices :

Sex

Female(s)

Type

Human

Action

Catch

Age

Adult (18-64 years)