ANTHROPOMORPHIC HAND ASSESSMENT PROTOCOL

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Purpose	Assessing the grasping ability of anthropomorphic artificial hands through 10 different grasp types or hand postures commonly adopted by the human hand in activities of daily living, quantifying functionality and human-like grasping.
Task Description	Grasp objects or make tasks with the artificial hand, one by one, adopting different prototypical postures specified for each object/task, and maintaining them under motion.
Setup Description	List of objects and their descriptions: The following objects of the YCB set are used for each of the 26 tasks: • Pulp pinch: small marker, plastic pear, washer 10 mm • Lateral pinch: bowl, XS clamp, key • Diagonal volar grip: Phillips screwdriver, spatula, skillet • Cylindrical grip: chips can, coffee can, power drill • Extension grip: plate, cracker box, chocolate pudding box • Tripod pinch: large marker, tuna can, golf ball • Spherical grip: plastic apple, softball, mini soccer ball • Hook: skillet lid, pitcher base, wood blocks with rope • Platform: plate • Index pointing/pressing: timer
	Initial and target poses of the objects: For each task the objects are handed over to the subject by an operator holding them in the correct position for successful execution of the grasp and released by the test operator once the grasp is performed by the artificial hand. For different hand geometry, kinematics or control strategies, small variations in the orientation to present the object can be allowed, always pursuing the correct grasp type.
	Description of the manipulation environment: The artificial hand is actuated by a subject (able-bodied person using an actuation or control device for the artificial hand or disabled person wearing the prosthesis). Some damping material should be used on the floor and table near the subject to protect the objects in case of a grasp failure.
Robot/Hardware/Software /Subject Description	Targeted robots/hardware/software: No robot is used. The hand is operated by a human subject (via an actuation or control device or worn as a prosthesis). Information about the actuation or control device or the prosthesis must be provided with the results, to evaluate the possible influence on the results. A fair comparison of different artificial hand designs is possible if the same actuation or control method is used for all of them.

	Initial state of the robot/hardware/subject with respect to the setup: The subject is in standing position during the test and located near a table.
	Prior information provided to the robot: The subject is instructed about the correct grasping posture for each object/task and is allowed to practice with the object during a minute prior to the test.
Procedure	The steps for each object are: 1. The operator shows the object and the correct grasping posture/task to the subject. Detailed information about the posture/task for each object and the order to be followed can be found in https://doi.org/10.1016/j.robot.2019.103259 (Table 1). 2. The operator helps the subject to practice the grasp/task until the subject feels comfortable or at maximum for one minute. 3. The operator hands the object over to the subject for the test. For index-pressing task the timer is fixed to the table surface. 4. The subject actuates the artificial hand to grasp the object with the palm pointing upwards. The operator releases the object as soon as the artificial hand has grasped the object. The subject maintains the grasp for three seconds. For the index-pressing task the subject presses the button to start the timer and waits for three seconds. This step is followed immediately by step 5 and the sequence of steps 4-5 is repeated three times. 5. While maintaining the grip, the subject rotates the hand in a natural way with low acceleration for the palm to point downwards (180º) and keeps the grip during three seconds in this position. For the index-pressing task the subject presses the button again to stop the timer (maximum time to execute three seconds). For the platform position this step is not executed. 6. The subject releases the object, which is taken by the operator.
Execution Constraints	The subject should try to reproduce the posture with the correct grasp type (GT) indicated by the operator with the artificial hand as accurate as possible. To evaluate the GT correctness the following instructions have to be considered for each GT: • *Index pointing, pressing:* The GT is considered correct if the palmar side or the tip of the distal phalange of the index finger is contacting the object and starting the timer (stopping for maintaining grip score). • *Platform:* The GT is considered correct if there is contact between the object and the palm and the angle between any phalange (long fingers and thumb) and the palm is less than 30º.

	- *Hook:* The GT is considered correct if there is contact between the object and the palmar side of at least three long fingers. - *Spherical grip:* The GT is considered correct if there is contact between the object and the palmar sides of the thumb, all the phalanges of at least three long fingers and the palm. - *Tripod pinch:* The GT is considered correct if the object is contacted by the radial side of the middle finger and by the palmar side of the distal phalanges of the thumb and the index finger. - *Extension grip:* The GT is considered correct if there is contact between the object and the palmar side of the distal phalange and the intermediate phalange (if exist) of at least three long fingers and the palmar side of the thumb. In any case, the angle between the distal phalange axes and the object side must be less than 30º. For the boxes the contact of the thumb and finger phalanges must be in the opposing sides of the box with the biggest surface area. - *Cylindrical grip:* The GT is considered correct if the angle between the main axis of the thumb and the main axis of the object's grip area is greater than 60º and there is contact between the object and the palmar sides of the thumb, all the phalanges of at least three long fingers and the palm. - *Diagonal volar grip:* The GT is considered correct if the angle between the plane defined by the thumb phalanges and the symmetry plane of the object is less than 30º and there is contact between the object and the palmar sides of the thumb, the palm and at least three long fingers. - *Lateral pinch:* The GT is considered correct if there is contact between the object and, at least, the palmar side of the distal phalange of the thumb and the radial side of the index finger. - *Pulp pinch:* The GT is considered correct if the object contacts with the palmar sides of the distal phalange of the thumb and the distal phalange of only one long finger, without any contact of the object with the palm.