Journal of Visualized Experiments

Measuring the functional abilities of children aged 3-6 years old with observational methods and computer tools

--Manuscript Draft--

Article Type:	Invited Methods Article - Author Produced Video
Manuscript Number:	JoVE60247R4
Full Title:	Measuring the functional abilities of children aged 3-6 years old with observational methods and computer tools
Section/Category:	JoVE Behavior
Keywords:	early care, computer applications, disabilities, assessment, functional abilities, special education, early childhood
Corresponding Author:	MARIA CONSUELO SAIZ MANZANARES Universidad de Burgos BURGOS-ESPAÑA, 34 SPAIN
Corresponding Author's Institution:	Universidad de Burgos
Corresponding Author E-Mail:	mcsmanzanares@ubu.es
Order of Authors:	MARIA CONSUELO SAIZ MANZANARES
	Raúl Marticorena Sánchez
	Álvar Arnaiz Gonzalez
	José Francisco Diez Pastor
	César Ignacio García-Osorio
Additional Information:	
Question	**Response**
Please indicate whether this article will be Standard Access or Open Access.	Standard Access (US$1200)

TITLE:

Measuring the Functional Abilities of Children Aged 3-6 Years Old with Observational Methods and Computer Tools

AUTHORS AND AFFILIATIONS:

María Consuelo Sáiz Manzanares[1], Raúl Marticorena Sánchez[2], Álvar Arnaiz González[2], José Francisco Díez Pastor[2], César I. García Osorio[2]

[1]Departamento de Ciencias de la Salud, Universidad de Burgos, Burgos, Spain
[2]Departmento de Ingeniería Informática, Universidad de Burgos, Burgos, Spain

Corresponding author:

María Consuelo Sáiz Manzanares (mcsmanzanares@ubu.es)

Email Addresses of Co-authors:

Raúl Marticorena Sánchez (rmartico@ubu.es)
Álvar Arnaiz González (alvarag@ubu.es)
José Francisco Díez Pastor (jfdpastor@ubu.es)
César I. García Osorio (cgosorio@ubu.es)

KEYWORDS:

early care, computer applications, disabilities, assessment, functional abilities, special education, early childhood

SUMMARY:

We present a protocol to use a computational tool to record and analyze the functional abilities of children aged 3-6 years old. The protocol facilitates the comparison of these abilities throughout their development and can be used to assess developmental difficulties.

ABSTRACT:

The analysis of functional abilities and their development in early childhood (0-6 years old) are fundamental aspects among young children with certain types of developmental difficulties that can facilitate prevention, through programmed interventions adapted to the needs of each user (student or patient). There are, however, few investigations to date, that have analyzed the use of automated tools for recording and interpreting the results of the initial assessment. Here, a protocol is presented to examine the functional abilities in early childhood in young children, aged between 3-6 years old, with intellectual disabilities, but the protocol can also be used for ages 0 to 6 years. The protocol makes use of a computer application, eEarlyCare, that facilitates the interpretation of the results of systematic observations, which are recorded in natural environments by professionals trained in early intervention. The software can be used to analyze 11 functional areas (Food Autonomy, Personal Care and Hygiene, Dressing and Undressing Independently, Sphincter Control, Functional Mobility, Communication and Language, Daily Life Routines, Adaptive Behavior and Attention) and a total of 114 different behaviors. Its use facilitates the analysis of the observed abilities and greatly assists early intervention. Compared

to other observational methods, it allows a more efficient use of personal and material resources. The use of the computer application facilitates the recording of the observation results, which helps with organization and reflection on the observations. The software displays the observation results on-screen compared to normal developmental parameters. This information can be referred to for decision-making about the most suitable intervention program for each user (student or patient). Likewise, clustering techniques are applied to analyze the relation between the type of intellectual disabilities and functional development identified with the software, a relation that is intended to serve as a guide for early-care professional intervention.

INTRODUCTION:

Observation at early ages: what and how to observe

Early childhood assessment in ordinary family contexts and at school is performed using the observational method. Hence, the evaluator must adhere to a precise observational process, the key to an accurate diagnosis and, therefore, to a successful training[1]. There are many development inventories that provide guidelines for assessment: The Portage Guide[2], the Brunet Lézine Scale[3], and the Battelle Developmental Inventory[4], among others. These tools are based on internationally agreed standards set by the scientific community in the field of human evolutionary development. Although these tools analyze developmental areas (Psychomotor, Cognitive, Communication and Language, and Autonomy and Socialization), recent studies[5] have proposed new tools that can also analyze these areas. These studies point out that the observational method from birth provides pointers of immense utility to early intervention and for the early detection of pathologies. However, the observational processes at these ages are complex, as they depend on behavioral observations recorded in natural contexts, which are not always easy to carry out.

Within this framework, the assessment of the acquisition of functional abilities at early ages is of great interest to parents, educators, and therapists alike. Any such assessment is of relevance for children who have been diagnosed or who are at risk of developing some disability. Early detection of developmental disorders is essential for the early diagnosis and intervention. Observational study from birth will provide indicators of this early detection and intervention[5]. Currently there are various tools (development inventories, scales, tests, etc.) for measuring development at those ages. The instruments that can currently be applied are developmental inventories, some of which are standardized. However, some of those instruments may require knowledge of psychometric techniques and the results are not automatically displayed on screen. For this reason, it is important to develop other tools that are easier to use and interpret.

Preparation of software for recording and interpreting data from the processes of contextual observation processes at early ages

The software development was, therefore, considered of relevance, which would assist the observers (therapist, educator, etc.) to record and to interpret the results of their observations. This protocol and software, eEarlyCare, can be used both in educational centers that work with children with disabilities and in therapeutic intervention centers aimed at this group. This is why from now on the term "user "will be used, which includes both students and patients, depending on the place where the intervention is carried out. In particular, a software that could facilitate

the recording and the interpretation of data gathered in natural contexts from the observation of functional abilities among children from 0 to 6 years old. This software, eEarlyCare, is based on the functional abilities scale[6] [Scale for the measurement of Functional Abilities in children between 0-6 years old] (SFA); this scale includes the measurement of 11 areas of development (Food Autonomy, Personal Care and Hygiene, Independently and dress and undresses, Sphincter control, Functional mobility, Communication and Language, Interactive symbolic play, Daily life routines, Adaptive behavior). Also, it was in turn, inspired by the Portage Guide[2], the Pediatric Evaluation of Disability Inventory (PEDI)[7], and the works of Bronson[8], as well as Whitebread and Basilio[4] on social skills at ages 0-6, the Brunet-Lézine Scale[3], developmental inventories for children aged 0-6[7], and the Assessment Scale of the precursors[9] to social skills. This tool is a computer application that is used for registering the results of each user assessment in longitudinal follow-ups (quarterly, monthly, annual, etc.). It is a referential aspect for the therapist with regard to the intervention, and for other professionals who work with children in early childhood with suspected dysfunctionalities. In addition, the software[10] can automatically produce comparisons between the development of the functional abilities of different users, regardless of whether they are at the same intervention center, thereby facilitating the definition of common aspects for collaborative work.

In particular, this software is based on mainstream technologies (e.g., Windows Presentation Foundation Development -WPF-[11]), a technological innovation that integrates advanced graphics to produce accurate graphic results[12] and a positive computer user-experience. The quality of the graphs improves the visualizations and the interactivity available with other tools such as spreadsheets. The application can store the data locally on relational databases and upload the information onto the cloud to be shared. In addition, the classic client-server architecture is also supported. These features make it easy to record the data that are collected from the observations and to process the results for visualization. Also, once registered, it is very easy to export the data. This allows the data to be used in powerful statistical packages to apply data mining techniques, such as supervised (classification and/or regression) and unsupervised (grouping) machine learning.

In this study, the classification techniques are of specific utility for personalized learning[13]. The architecture can be seen in **Figure 1** and **Figure 2**. In **Figure 1**, the functionality of cloud storage is used as a safeguard, in case of data security problems and potential loss and corruption of data when exchanged between applications. Additionally, the software can also operate in a classic network-based client-server architecture with a database (**Figure 2**) with all data exchanges taking place between clients (these are concepts that are used in the field of computer science). These platforms provide authentication mechanisms and restricted access, which ensure privacy and data protection, while facilitating interaction with fully developed applications. The final result is an application interface that is designed[14] for early-care professionals, so that they can use Learning Analytics techniques in a simple way and refer to them, in order to follow up the degree of each student's development in each evaluation area of the scale[15].

The application also offers a general profile of each user in each of the functional areas and subareas (**Table 1**). It also produces a comparison between all users at any one center. In brief, it

produces a personalized analysis of the intervention needs of the different users. In addition, it helps early-care professionals with their intervention programs, as it can flag up areas in which users might or might not show similar developmental patterns. All these results guide the type of intervention programs that can be used together, rather than those that have to be designed individually. The data that are linked to this interface are the SFA scores of the users that are measured on a Likert scale from 1 to 5. Those scores can be compared with the maximum developmental age scores linked to each SFA dimension. The software can also link the chronological age of each user to the developmental age of each SFA dimension; a relevant aspect for the detection of intervention areas from among which to prioritize the areas for treatment.

[Place Table 1]

[Place Figure 1 and Figure 2 here]

Therapists and intervention professionals can use this assessment protocol and the software implementation for the assessment of functional abilities and their development in early childhood between 0 and 6 years of development. The software can be used with children within that age range, although it is especially useful for children with suspected impaired development of functional abilities. It is likewise especially useful at Special Education Centers. The Research question is whether, having observed the functional abilities of children, the use of a computer tool will facilitate the recording and the interpretation of the results for the therapist.

PROTOCOL:

This protocol was performed in compliance with the procedural regulations of the Bioethical Committee of the University of Burgos (Spain). Prior to their participation, both the students and their parents and in some cases legal tutors had all provided their informed consent and had been fully made aware of the objectives of study. No financial compensation was offered for their participation.

1. Participant recruitment

1.1. Recruit children between 0-6 years of age with a history of special educational needs related to alteration in the areas of motor development, cognitive, personal autonomy, and socialization and with moderate to severe intellectual disabilities. A total of 11 participants (7 boys and 4 girls) were recruited for the present study.

1.2. Include children who have been diagnosed with an intellectual disability (moderate or severe) in accordance with the Diagnostic and Statistical Manual of Mental Disorders (DSM-5)[16] and attend a Special Education Center for their schooling (**Table 2**).

[Place **Table 2** here]

NOTE: In each case (depending on the detection of the problem and the place where the

intervention is performed), the diagnosis should have been confirmed by a pediatric neurologist at a hospital or a psychologist within a multidisciplinary team, in accordance with DSM-5. Ideally, there should be no fewer than 15 participants, since the insertion of the observation results is laborious.

1.3. Exclude children with normal development in functional areas (motor, cognitive, personal autonomy and socialization development) and children with an Intellectual functioning limitation.

2. Data collection

2.1. Collect data on the development of the children in different functional areas (Food Autonomy, Personal Care and Hygiene, Dressing and Undressing Independently, Sphincter Control, Functional Mobility, Communication and Language, Daily Life Routines, Adaptive Behavior and Attention).

2.2. Perform the observation using the Scale for the measurement of functional abilities (SFA)[5] in children between 0-6 years old (SFA) (**Table of Materials**) and conduct the observation in a natural context (e.g., school settings).

2.3. Record observations throughout the week in different natural environments that reflect the daily life of the students at the center (**Table 1**) (e.g., while playing, etc.).

2.3.1. Let the teacher or the therapist directly attending the children at the educational institutions record the observations. Gather the observations for each functional area.

NOTE: Prior to data observation, three training sessions should be conducted for teachers or therapists. These sessions must be conducted by a psychologist or a professional with experience in early-childhood assessment.

2.4. Input the results into the software for the assessment of functional abilities in early childhood between 0-6 years old. The details on how to use the software is provided in step 3.

3. Experimental procedure

3.1. Assigning a student to a teacher in the software

NOTE: This step has to be carried out by the director or coordinator of the center where the intervention takes place.

3.1.1. Log in to the software package with a username (professional) and password and select the language: English or Spanish.

3.1.2. Enter the student data information from the records held by the director of the center.

3.1.3. Fill in the following fields for each student: Name, Surname, Code, Sex, Date of Birth, Developmental Age, Primary Diagnosis, Secondary Diagnosis, where appropriate, and observations that are relevant to medication data, allergies, and other information of interest to the management of the center.

3.1.4. Enter the teacher or therapist information from the records held at the center.

3.1.5. Assign the students to a group with a teacher (or therapist) by clicking on **Classroom**. Go to the column **Students**, choose the student to be assigned to the classroom, and click on **Teachers** and select one.

3.1.6. Allocate each group of students and their teacher (or therapist) to a classroom by clicking on **Teachers**, input dates, name, surname, identification code, mail, passwords and observations. Click **Accept**.

NOTE: The director or coordinator of the center assigns a role for each teacher or therapist to carry out the evaluations of each student or patient (as explained above, it depends on the type of center). The director or coordinator of the center can also consult the evaluations that the teacher or therapist has made.

3.2. Use of the software by the teacher

NOTE: The teacher or therapist performing the assessment can then select an academic year and/or a term. The scale offers the possibility of selecting different functional areas for each term (**Table of Materials**).

3.2.1. Log in to the software with the username (professional) and the password previously assigned by the director of the center.

3.2.2. Enter the results of the assessments completed in natural environments for each participant assigned to the classroom.

3.2.3. Choose a student in the software by clicking on his/her name, and start the assessment of the different functional areas (detailed in step 2.3.1).

NOTE: The teachers or therapists can stop the assessment of each student at any time and continue at another time, having saved the data that they have registered.

3.2.4. Perform the comparative analysis between the development of each user and the expected development at that chronological age.

3.2.4.1. Once the data is registered, select the column **Evaluation** by right clicking. Then select the year and the trimester.

3.2.4.1. Select the column **Students** and select the students of a class of whom to make the evaluation. Select the column **Areas** clicking on the area or subarea that needs to be evaluated.

3.2.4.2. Click on the **Maximum** tab. It gets the information about the students and the comparison with the development expected for their age.

NOTE: This offers a user (student or patient) or development profile for a given functional area with a comparative link to the highest expected scores for the chronological age of the user (student or patient).

3.2.5. Compare the different functional areas of each user from the classroom. An analysis of the functional areas of each user can be performed with the software. Following step: once the data is registered, select the column **Evaluation** by right clicking. Then select the year and the trimester. Select the column **Students** and select the students of all classes. Select the column **Areas** and click on the area or subarea to evaluate.

3.2.5.1. Click on the **Maximum** tab. It gets the development of the students and the comparison with the development expected for their age.

3.3. Exporting data from the software

3.3.1. Select the user data and functional areas, and export the database. Select the column **Excel** to get the database. Export the database in the statistics program or library of choice.

3.3.2. Import the data into statistical packages and libraries such as SPSS, Weka, Python's scikit-learn, etc. and perform clustering analysis. Here, analysis with SPSS is detailed as below.

NOTE: Clustering or cluster analysis is an 'unsupervised' machine-learning technique, and, within *k*-means, it is a grouping method, which aims to partition a set of *n* observations into *k* groups, in which each observation belongs to the group with the closest mean value. In this experiment, *k*-means clustering was used to check the clusters of children and their functional development measured with SFA.

3.3.2.1. Select the option **Analyze** and **Classify** followed by the option ***k*-means cluster** in the statistical package.

3.3.2.2. Select crosstabs under **Descriptive Statistics**, and the following two variables: the cluster variable of 'belonging to a group' and the degree variable ('moderate' or 'severe').

NOTE. This correspondence is important, because it offers the teacher or therapist information on the homogeneous functional development of users that goes beyond the diagnosis, providing information to propose similar intervention programs in some areas of functional development. This option is expected to facilitate full use of the educational or therapeutic service and its

personal and material resources.

3.3.2.3. Select the **Descriptive Statistics** option and select crosstabs and the **Cohen Kappa Coefficient** option.

NOTE: The Cohen Kappa coefficient is a statistic which measures inter-rater agreement for qualitative (categorical) items. It is generally thought to be a more robust measure than simple percent agreement calculations, as *k* accounts for the possibility of the agreement occurring by chance. This coefficient provides an indicator of the reliability of the relationship found between the diagnostic classification in moderate-to-severe intellectual disabilities and the clustering of the developmental results obtained with the software.

3.3.3. Use the spreadsheet to generate the spider chart and specific bar graphs for the groups of children with moderate and severe intellectual disabilities.

REPRESENTATIVE RESULTS:

The present study recruited 11 participants with confirmed diagnoses [both moderate (development quotient = DQ 40-65) and severe (DQ 39-60) intellectual disabilities]. The protocol was tested in a pilot project over 20 months at a Special Education Center. All the diagnoses for this study had been confirmed by a multidisciplinary team in accordance with DSM-5, using the Brunet Lézine Scale, as the degree of affectation was beyond the scope of other scales such as the Wechsler Preschool and Primary Scale of Intelligence (WPPSI). However, the ages of the participants slightly exceeded the chronological age of 6 (**Table 2**). The actions carried out and the application times in this study can be found in **Table 3**.

[Place **Table 3** here]

A comparative analysis can be performed once the professional (teacher or therapist) enters the data in the software. The development of users (students or patients) from the same classroom on the different dimensions of the scale is shown.

In this study, we present some examples of data analysis with the observational protocol coupled with the use of the software. We first performed a cluster analysis, in order to check whether the diagnoses of both medium and severe intellectual disabilities of the children with special educational needs corresponded to their actual development. Using the k-means method, we found 2 clusters belonging to either group. Cluster 1 and Cluster 2 integrated 55% and 45% of the sample, respectively. A cross-table was then constructed to study the relationship between membership of a group cluster and the variable 'degree of disability'. It was found that all the subjects grouped in Cluster 1 belonged to group a) (moderate intellectual disabilities) and Cluster 2 included all the students belonging to group b) (severe intellectual disabilities) and there was only one with moderate intellectual disabilities (**Table 4**). A Cohen Kappa coefficient = .820, p = .006 was obtained.

[Place **Table 4** here]

The software can, therefore, record the development of the functional abilities of the children under treatment at the same (education or therapy) center and can determine similar and different levels of development. This aspect is very important, as it will facilitate the application of similar intervention programs among children with similar needs, which will in turn facilitate personalized intervention and efficient use of resources.

Progressing with this analysis, a study can be performed of the abilities of the participants in each functional group (disability moderate vs. disability severe). Both Spider and specific bar graphs were used for this purpose see **Figure 3** and **Figure 4**.

[Figure 3 and Figure 4 about here]

FIGURE AND TABLE LEGENDS:

Figure 1: Architecture of the proposal of automation of the correction of the Scale functionality of cloud storage

Figure 2: Architecture of the proposal of automation of the correction of the Scale functionality classic network

Figure 3: Comparative analysis between development of each user (student or patient) and the expected development in children with several intellectual disabilities. (**A**) Food Autonomy, (**B**) Personal Care and Hygiene, (**C**) Independently dress and undresses, (D) Sphincter control, (**E**) Functional mobility, (**F**) Communication and Language, (**G**) Interactive and symbolic play, (**H**) Daily life routines, (**I**) Adaptive behavior. Blue line indicates skill acquisition score. Garnet line indicates maximum score. Error bars included in **A**, **B**, **C**, **D**, **E**, **F**, **G**, **H** and **I**. The error bars are graphical representations of data variability, an error bar indicates the uncertainty of a value. The x-axis represents the participants (with several intellectual disabilities) and the y-axis represents the scores they have obtained in each functional area. The spider graph shows the comparative development of the participants in each functional area.

Figure 4: Comparative analysis between development of each user (student or patient) and the expected development in children with moderate disabilities. (**A**) Food Autonomy, (**B**) Personal Care and Hygiene, (**C**) Independently dress and undresses, (**D**) Sphincter control, (**E**) Functional mobility, (**F**) Communication and Language, (**G**) Interactive and symbolic play, (**H**) Daily life routines, (**I**) Adaptive behavior. Blue line indicates skill acquisition score. Garnet line indicates maximum score. Error bars included in **A**, **B**, **C**, **D**, **E**, **F**, **G**, **H** and **I**. The error bars are graphical representations of data variability, an error bar indicates the uncertainty of a value. The x-axis represents the participants (with moderate intellectual disabilities) and the y-axis represents the scores they have obtained in each functional area. The spider graph shows the comparative development of the participants in each functional area.

Table 1: List of functional areas and subareas.

Table 2: Characteristics of the sample

Table 3: Process to observation in different functional areas

Table 4: Cross Table Disability Cluster Case Number

DISCUSSION:

When using the software, it is recommended that the teacher or therapist record the development of each child's functional abilities over at least for two sessions. The scale contains 114 items, 11 functional areas, which are divided into 33 functional subareas and the assessment should be the result of observation in natural contexts. In addition, the software allows early-care professionals to record evaluation data with ease and to analyze the data displayed in individual and group graphs, highlighting the development of the users, students or patients, assigned to the classroom in all functional areas and subareas.

The software also facilitates data exportation from a center and classroom to text files (e.g., .csv, .json,) and other spreadsheet formats (e.g., .xlsx), facilitating their transfer to statistical packages, and specific Machine Learning libraries, where it is possible to perform other more complex analyses, such as cluster analysis, mean differences with parametric and/or non-parametric statistics, and reliability analyses of the software for that sample, among many others. In this case, we applied non-parametric statistics with statistical software packages.

The use of the software was only tested at one center, so the work is underway to extend its application to other service centers for users with disabilities. Similarly, and from a perspective of continuous improvement, work is also underway to develop a second phase of the software, in which the possibility will be offered of implementing individualized early stimulation programs, based on the detection of the most affected area or functional areas of development that will be automatically generated. These programs will include the behaviors to be implemented in hierarchical order of acquisition need, as well as specific guidelines for intervention, the necessary materials, time and space for implementation and generalization activities, and a monitoring and evaluation template similar to the one presented for the assessment phase.

It is worth noting that the use of a protocol for the observation of functional abilities that offered no automated processing of the information to be interpreted by the professional, could neither obtain the results for their interpretation in real time, nor conduct the statistical analyses that would guide the subsequent practice of therapeutic intervention.

As a general conclusion, it may be noted that the use of the software has facilitated both the recording and the interpretation of the results by the therapists. Those functional aspects were highly valued in a very positive light, both by the director of the center and the therapists participating in this study.

This method has very few limitations on its implementation, in terms of both material resources

(computer characteristics, application requirements) and personal resources (degree of prior knowledge for use of the software application and for the interpretation of the results by the professional recording the observations). The use of the application is not complicated. The most important difficulty can be found in the processing of the database with statistical packages, at which point more sophisticated data calculation and computation abilities are required.

Similarly, and from the perspective of continuous improvement, work is underway to develop a second phase of the software, in which the possibility will be offered of implementing individualized early stimulation programs based on the detection of the most affected area or functional areas of development that will be automatically generated. These programs will include the behaviors to be implemented in hierarchical order of acquisition need, as well as specific guidelines for intervention, necessary materials, time and space for the implementation, and the generalization of activities, and a monitoring and evaluation template similar to the one presented in the assessment phase.

The use of the tool presented here and the proposed improvements in addition to the field work in institutions that work with children with some development affectation will serve the work of researchers in this field and also for programmed use from government institutions, since it facilitates both the registration and the interpretation of the results.

ACKNOWLEDGMENTS:

We wish to thank the Vice-rectorate for Research and Knowledge Transfer of the University of Burgos for making the development of the software possible through the "VI Edición Convocatoria Prueba Concepto: Impulso a la valorización y comercialización de resultados de investigación" [VI Edition of the Call for Proof of Concept: Impulse to the valorization and marketing of research results]. We likewise thank the Educational Programs Area of the Provincial Directorate of Education and to the Special Education Center "Fray Pedro Ponce de León", both in Burgos (Spain), and to the families of the children who agreed to participate in this pilot study with prior informed consent, without whose collaboration the software (eEarlyCare) would not have been possible. The video was edited by Alberto Calvo Rodríguez TVUBU technician and the voice over was done by Caroline Martin, from the Department of English Philology of the University of Burgos.

DISCLOSURES:

The authors declare that they have no competing financial interests.

REFERENCES

1. Sáiz, M.C. Intervención cognitiva en niños pequeños [Cognitive intervention in early children]. In *Intervención Temprana: Desarrollo óptimo de 0 a 6 años* [Early Intervention: Optimal development from 0-to-6 years old]. Edited by Gómez, A., Viguer, P., Cantero, M.J., 117–133, Síntesis. Madrid, Spain (2003).

2. Bluma, M. S., Shearer M.S., Frohman, A.H., Hilliard, J.M. Portage Guide to Early Education (2nd Edition). Cooperative Educational Service Agency. Wisconsin, United States (1978).

3. Josse, D. *Escala de desarrollo psicomotor de la primera infancia Brunet-Lézine Revisado* [Scale

of psychomotor development of early childhood (Brunet-Lézine-Revised)]. Psymtéc. Madrid, Spain (1997).
4. Newborg, J. *Battelle Developmental Inventory, 2nd Edition: Examiner's manual*. Itasca, IL: Riverside, USA (2005).
5. Whitebread, D., Basilio, M.S. Emergencia y desarrollo temprano de la autorregulación en niños preescolares [The emergence and early development of self-regulation in preschool children]. *Profesorado. Revista de Currículum y Formación del Profesorado*. **16** (1), 1–20 (2012).
6. Pérez, Y., Sáiz, M.C. *Escala para la medición de habilidades funcionales en edades 0-6 años (EHFI)* [Scale for the measurement of functional abilities in 0-to-6-year olds (SFA)]. Registration number 00/2019/4253 (2018).
7. Haley, S.M., Coster, W.J., Ludlow, L.H., Haltiwanger, J.T., Andrellos, P.J. *The Pediatric Evaluation of Disability Inventory (PEDI)* (2nd ed.). Pearson Clinical Assessment. Washington, United States (2012).
8. Bronson, M.B. *Self-regulation In Early Childhood*. The Guilford Press. NY, United States (2000).
9. Sáiz, M.C., Carbonero, M.A. Metacognitive Precursors: An Analysis in Children with Different Disabilities. *Brain Science*. **7** (10), 1–14 (2017).
10. Sáiz, M .C., Marticorena, R., Arnaiz-González., Díez-Pastor, J. F. *eEarlyCare Computer application*. Registration number 00/2019/3855. Burgos, Spain (2019).
11. Chowdhury, K. *Windows Presentation Foundation Development Cookbook.* (1st Edition). Packt Publishing. Birmingham (2018).
12. Nogal, F., Marticorena, R. *UBUGrades 2.0. Doctoral Degree dissertation*. Universidad de Burgos. Burgos, Spain (2018).
13. Sáiz, M.C., Marticorena, R., Arnaiz-Gonzalez, Á., Díez-Pastor, J.F., Rodríguez-Arribas, S. Computer application for the registration and automation of the correction of a functional abilities detection scale in early care. *Proceeding of INTED2019: 13th annual International Technology, Education and Development Conference*, 5322-5328, IATED Academy. Valencia, Spain (2019).
14. Hartson, R., Pyla, P.S. The UX book: *Process and guidelines for ensuring a quality user experience*. Morgan Kaufmann. Amsterdam, Dutch (2012).
15. Bernal, R., Ramírez, S.M. Improving the quality of early childhood care at scale: The effects of ''From Zero to Forever". *World Development*. **118**, 91–105 (2019).
16. American Psychiatric Association. *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5). (5th Edition). American Psychiatric Association, Arlington, VA, United States (2013).

Figure 1

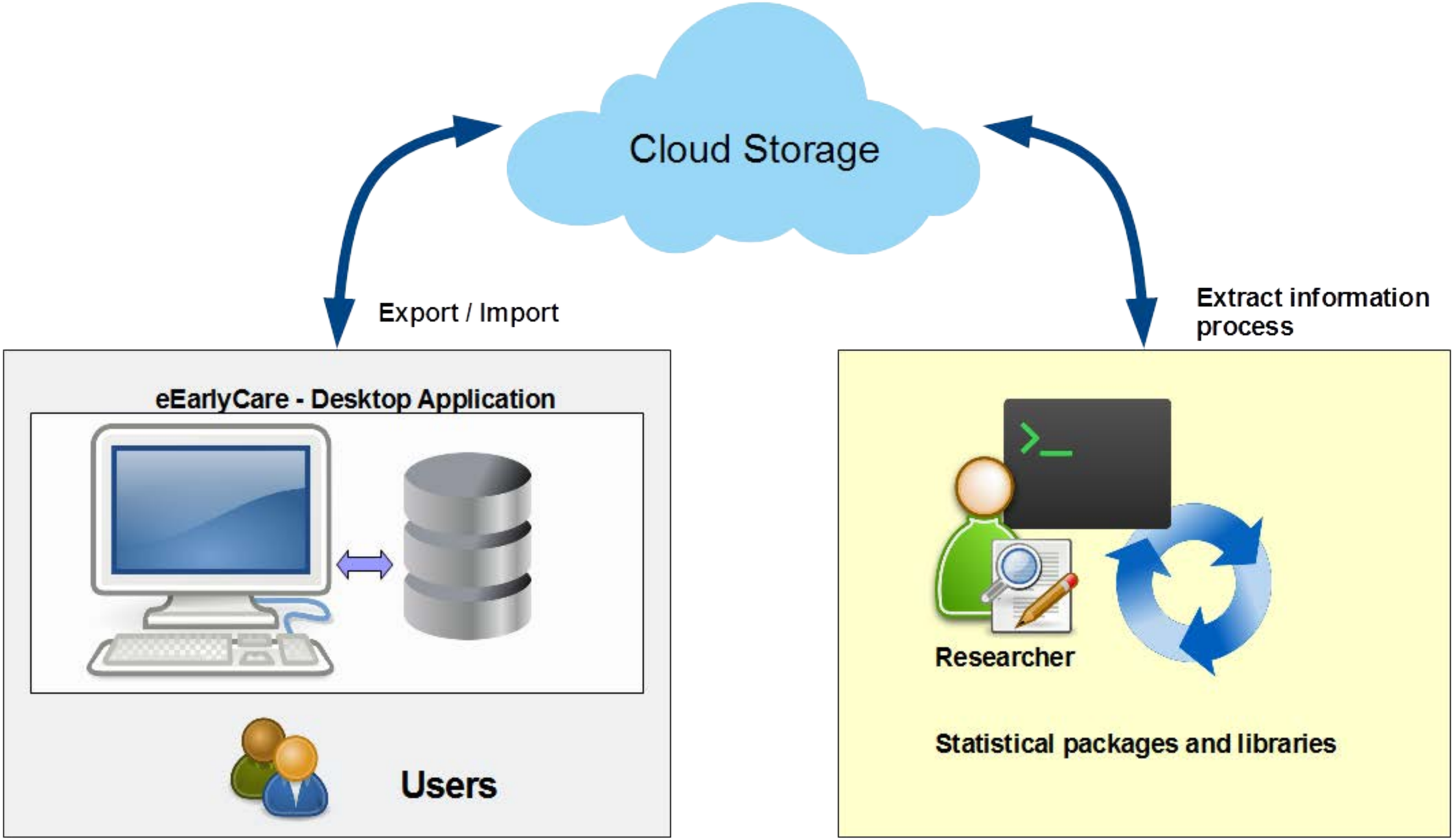


Figure 2

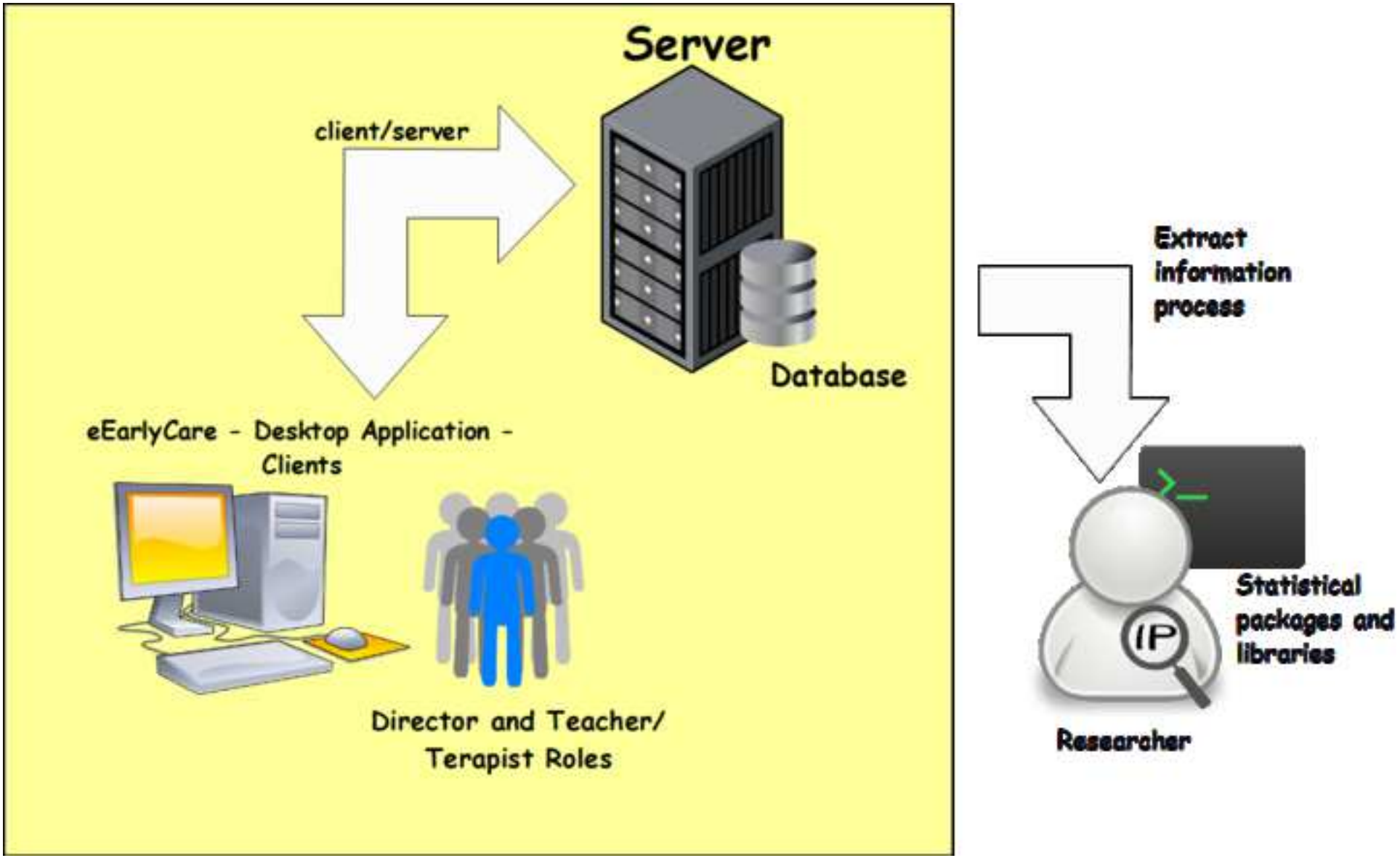
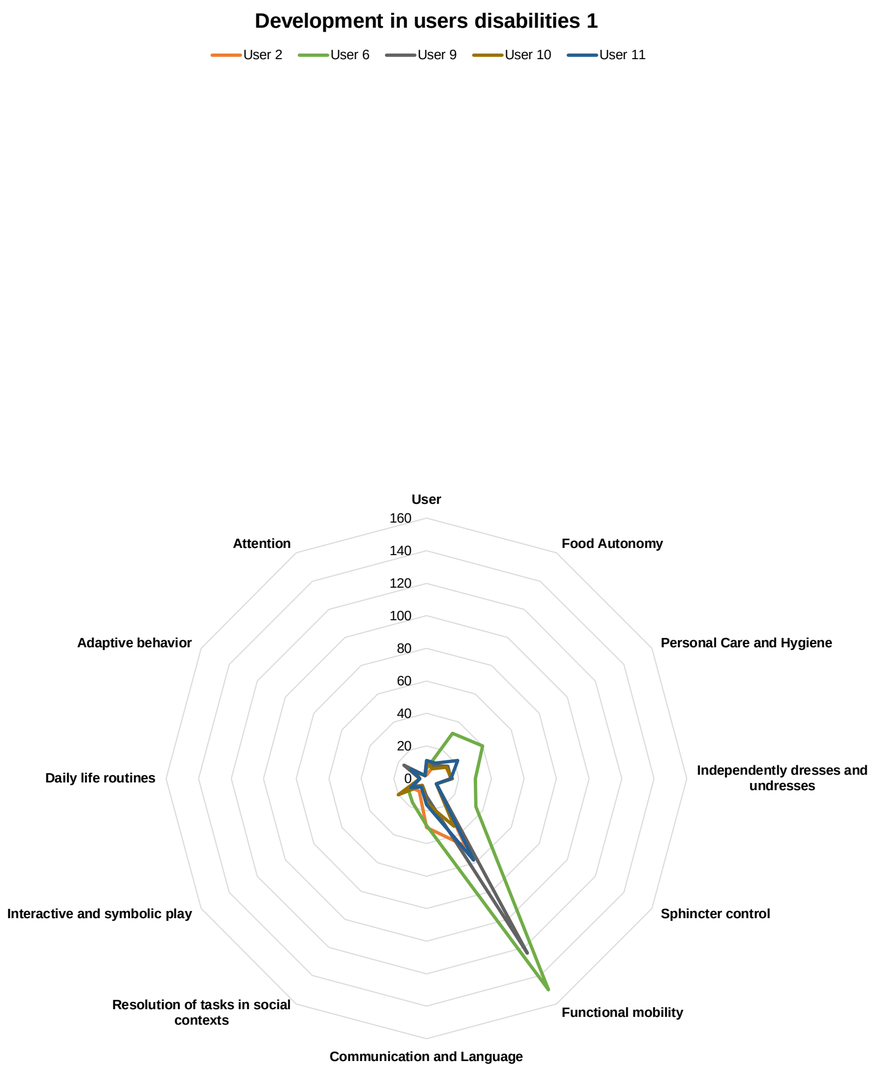


Figure 3

Click here to access/download;Figure;Figure_3.pdf



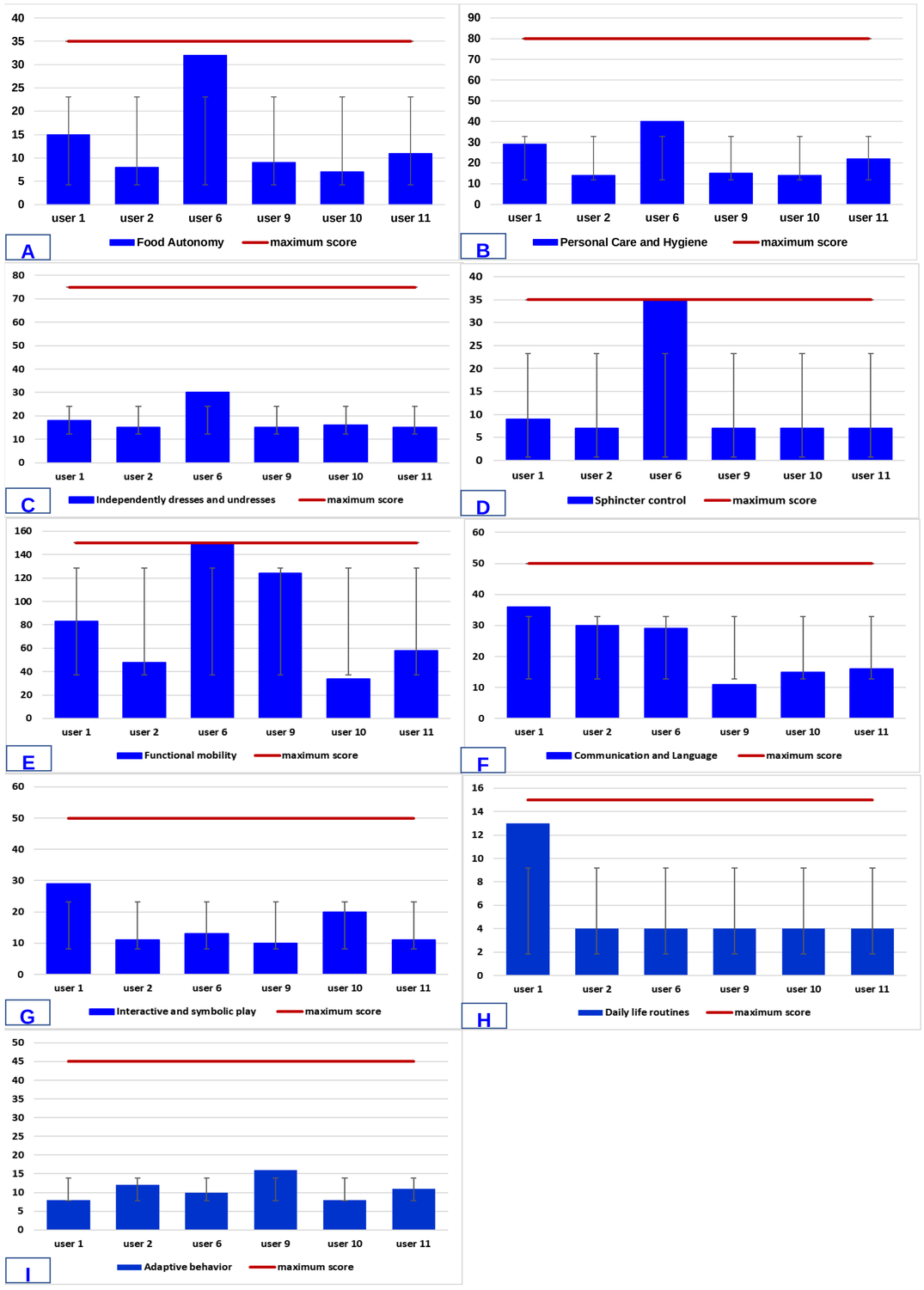
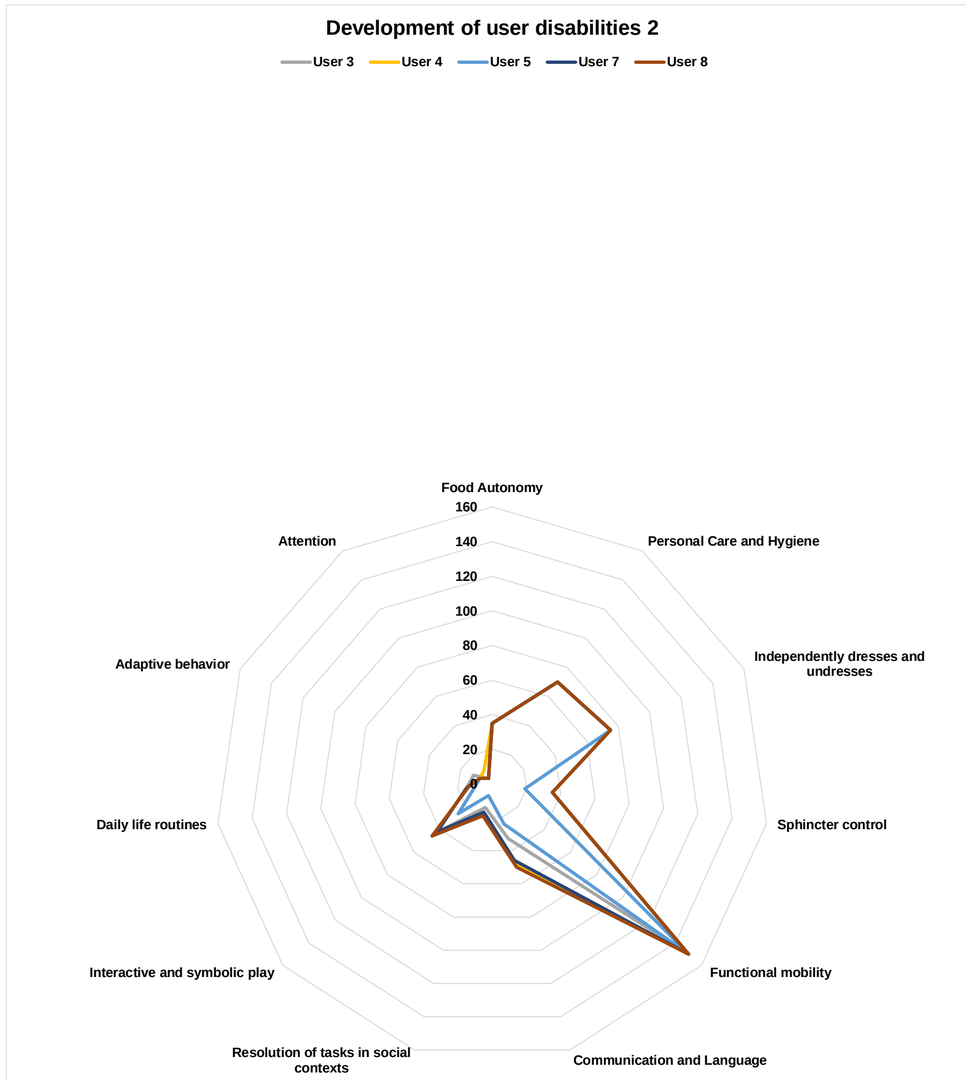


Figure 4

Click here to access/download;Figure;Figure_4.pdf



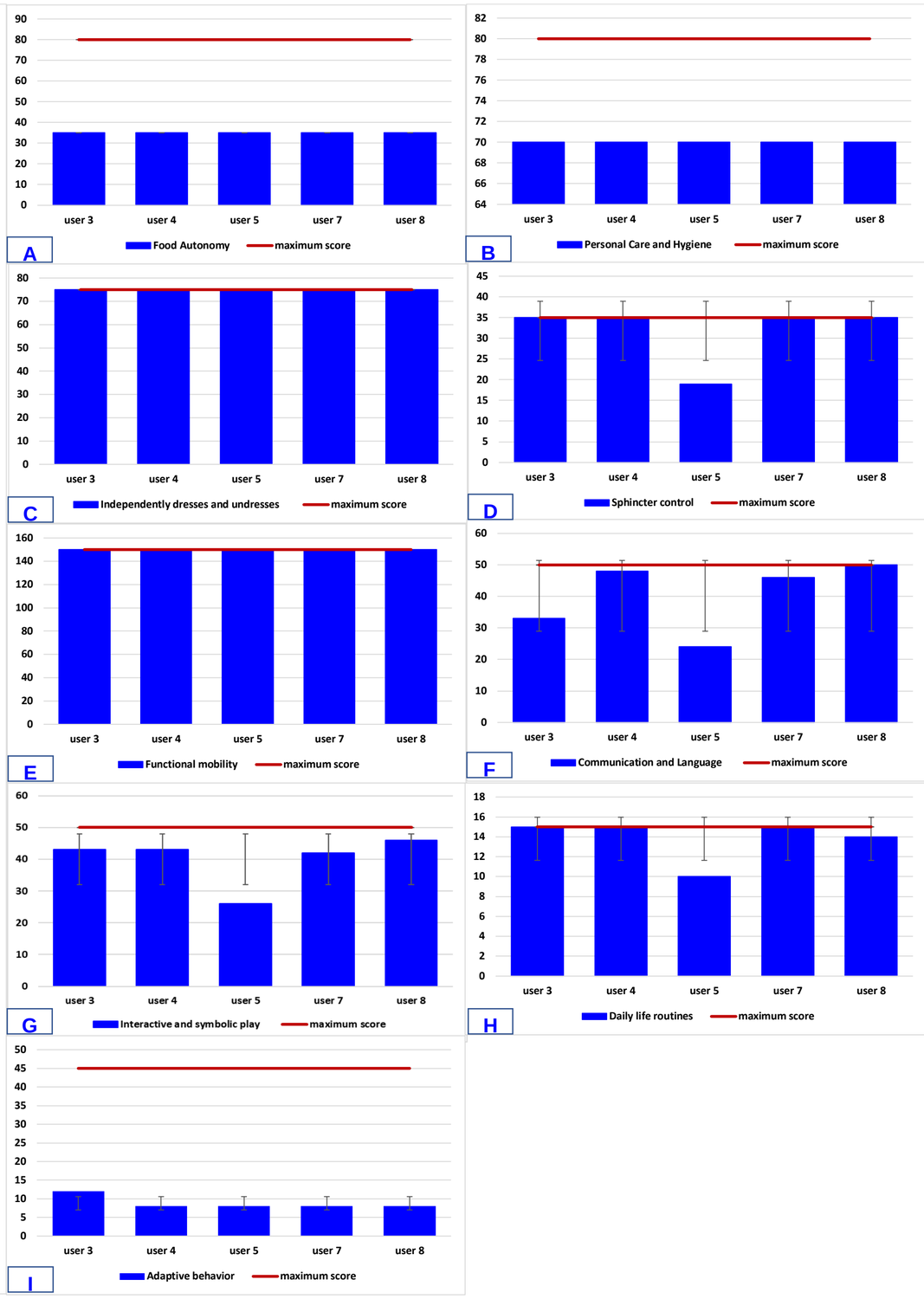


Table 1

Functional area
1. Food Autonomy
2. Personal Care and Hygiene
3. Independently dresses and undresses
4. Sphincter control
5. Functional mobility
6. Communication and Language
7. Resolution of tasks in social contexts
8. Interactive and symbolic play
9. Daily life routines
10. Adaptive behavior
11. Attention

Functional sub-area
1. Food Texture
2. Use of utensils
3. Dental Hygiene
4. Hairstyle
5. Nasal Care
6. Handwashing
7. Face and body wash
8. Dressing and undressing (waist upwards)
Dressing and undressing (waist downwards)
9. Sphincter control
10. Upper extremity
11. Transfers in WC
12. Transfers on a chair
13. Mobility and bed transfers
14. Mobility in the bathtub
15. Mobility indoors
16. Transport of objects
17. Outdoor Mobility
18. Word comprehension
19. Understanding phrases
20. Functional use of communication
21. Solving Problems
22. Information about yourself
23. Interactive Play
24. Interaction with the peer group
25. Play with objects
26. Guidance in time
27. Homework
28. Self-harm behavior
29. heteroagressiveness (harming others)
30. Destruction of objects
31. Disruptive behaviour (cry, shout, laugh without reason)
32. Stereotypes
33. Attention

Table 2

Sex	*n*	M_{age}	SD_{age}	Rank age (months)	Disability degree*	
					a	b
Boys	7	95.2	11.77	86-114	4	3
Girls	4	83.5	23.56	45-112	1	3

NOTE:* Degree of disability: a = moderate intellectual disability; b = severe intellectual disability; Type

Schooling	
c	d
2	5
2	2

e of Schooling: c = Combined Schooling; d = Schooling in a Specific Special Education Center; M = Mean

age in months; SD = Standard Deviation. * The children were diagnosed using the criteria of DSM516

Functional area	Time	Location
Food Autonomy	1 week	During meals in natural contexts.
Personal Care and Hygiene	1 week	In care and hygiene activities in natural contexts. (center or home)
Dressing and undressing independently	1 week	During the task of dressing and undressing in natural contexts. (center or home)
Control of sphincters	1 week	During the daytime in the natural context. (center or home)
Functional mobility	1 week	During the activities of daily life in natural contexts. (center or home)
Communication and language	1 week	During the activities of daily life in natural contexts. (center or home)
Resolution of tasks in social contexts	1 week	During activities of daily living in natural contexts (center or home)
Interactive and symbolic play	1 week	Situations of symbolic play in natural contexts., (center or home)
Daily life routines	1 week	During the activities of daily life in natural contexts. (center or home)
Adaptive behavior	1 week	During the activities of daily life in natural contexts. (center or home)
Attention	1 week	During the activities of daily life in natural contexts. (center or home)

NOTE: *Either the teacher or the therapist will contrast the results of the observations gathered at the center with the information gathered from the family, to see whether there are any discrepancies. Prior agreement and consent were always sought from the family, before observation at home in natural contexts that were recorded in video format for subsequent analysis. The number of observations was established according to the type of functional ability, establishing the criterion of different observations during one week in a natural context (center or home).

Responsible*
Teacher or Therapist
Teacher or Therapist
Teacher or Therapist
Teacher or Therapist
Teacher or Therapist
Teacher or Therapist
Teacher or Therapist
Teacher or Therapist
Teacher or Therapist
Teacher or Therapist
Teacher or Therapist

Table 4

		Cluster case number		Total
		1	2	
Disabilities	a	5	0	5
	b	1	5	6
Total		6	5	11

Name of Material/ Equipment	Company	Catalog Number
eEarlyCare software	Authors and University of Burgos. Register number 00/2019/3855	
Scale for the measurement of functional abilities in 0-6 years old (SFA)	Authors and University of Burgos. Register number 00/2019/4253	

Comments/Description
Computer application to implement SFA
Scale for the measurement of functional abilities in 0-6 year olds

Rebuttal Letter

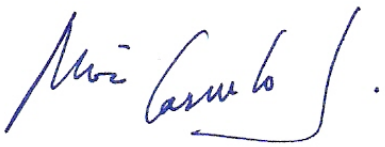
Dear Editor,

We have made the following changes based on your suggestions:

Suggestion 1. Figure 3: Where is User 1 in the spider graph? Please revise the x-axis labels for Panels C, D, E, F, G, H, and I. It appears to show Users 1, 2, 3, 4, 5, and 6 but you mean to write Users 1, 2, 6, 9, 10, 11 as in Panel A and Panel B.
Change 1 made I`m sorry, when making the graph, the number of users was not selected, only the row. The graph has been corrected and now they all appear numbered with the user number according to the disability classification category which in this case is severe.
Suggestion 2. Figure 4: Please revise the x-axis labels for Panels G. It appears to show Users 1, 2, 3, 4, 5 but you mean to write Users 3, 4, 5, 7, 8 as in the rest of the Panels.
Change 2 made: Excuse me, the same mistake that occurred in the previous case has been corrected.
Suggestion 3. Please define the error bars for Figure 3 and 4 in the written manuscript.
Change 3 made: We have included the meaning of error bars in Figure 3 and Figure 4 within the manuscript in the legend below. The change has been introduced in purple to distinguish it from previous revisions.
Suggestion 4. Do you intend to publish the consent form with the published manuscript? By including them as supplementary files, they will be published with the manuscript. Please consider removing them from your submission.
Change 4 made: No, of course, we only included it so that you would have it. Feel free to remove it.
Suggestion 5. In the video, please revise Figures 3 and 4 as well. Furthermore, Figures 3 and 4 at 10:45 are very hard to read. Please consider splitting up the figures and showing them sequentially instead of side by side.
Change 5 made: We have changed Figures 3 and 4 in the video since the update.
Suggestion 6. Please shorten the title card at the end to be 3-5 seconds total.
Change 6 made: We shortened the video in the final part by 3-5 seconds.

Thank you very much for the accuracy of the review, we hope the manuscript can be published soon. We remain at your disposal for any further changes needed.

Sincerely



María Consuelo Sáiz Manzanares

1 Alewife Center #200
Cambridge, MA 02140
tel. 617.945.9051
www.jove.com

ARTICLE AND VIDEO LICENSE AGREEMENT

Title of Article:	Measuring the Functional Abilities of Children with Observational Methods and Computer Tools
Author(s):	María Consuelo Sáiz Manzanares, Raúl Marticorena Sánchez, Álvar Arnaiz González, José Francisco Díez Pastor, César I. García Osorio

Item 1: The Author elects to have the Materials be made available (as described at http://www.jove.com/publish) via:

☒ Standard Access ☐ Open Access

Item 2: Please select one of the following items:

☒ The Author is **NOT** a United States government employee.

☐ The Author is a United States government employee and the Materials were prepared in the course of his or her duties as a United States government employee.

☐ The Author is a United States government employee but the Materials were NOT prepared in the course of his or her duties as a United States government employee.

ARTICLE AND VIDEO LICENSE AGREEMENT

1. **Defined Terms.** As used in this Article and Video License Agreement, the following terms shall have the following meanings: "**Agreement**" means this Article and Video License Agreement; "**Article**" means the article specified on the last page of this Agreement, including any associated materials such as texts, figures, tables, artwork, abstracts, or summaries contained therein; "**Author**" means the author who is a signatory to this Agreement; "**Collective Work**" means a work, such as a periodical issue, anthology or encyclopedia, in which the Materials in their entirety in unmodified form, along with a number of other contributions, constituting separate and independent works in themselves, are assembled into a collective whole; "**CRC License**" means the Creative Commons Attribution-Non Commercial-No Derivs 3.0 Unported Agreement, the terms and conditions of which can be found at: http://creativecommons.org/licenses/by-nc-nd/3.0/legalcode; "**Derivative Work**" means a work based upon the Materials or upon the Materials and other pre-existing works, such as a translation, musical arrangement, dramatization, fictionalization, motion picture version, sound recording, art reproduction, abridgment, condensation, or any other form in which the Materials may be recast, transformed, or adapted; "**Institution**" means the institution, listed on the last page of this Agreement, by which the Author was employed at the time of the creation of the Materials; "**JoVE**" means MyJove Corporation, a Massachusetts corporation and the publisher of The Journal of Visualized Experiments; "**Materials**" means the Article and / or the Video; "**Parties**" means the Author and JoVE; "**Video**" means any video(s) made by the Author, alone or in conjunction with any other parties, or by JoVE or its affiliates or agents, individually or in collaboration with the Author or any other parties, incorporating all or any portion of the Article, and in which the Author may or may not appear.

2. **Background.** The Author, who is the author of the Article, in order to ensure the dissemination and protection of the Article, desires to have the JoVE publish the Article and create and transmit videos based on the Article. In furtherance of such goals, the Parties desire to memorialize in this Agreement the respective rights of each Party in and to the Article and the Video.

3. **Grant of Rights in Article.** In consideration of JoVE agreeing to publish the Article, the Author hereby grants to JoVE, subject to **Sections 4** and **7** below, the exclusive, royalty-free, perpetual (for the full term of copyright in the Article, including any extensions thereto) license (a) to publish, reproduce, distribute, display and store the Article in all forms, formats and media whether now known or hereafter developed (including without limitation in print, digital and electronic form) throughout the world, (b) to translate the Article into other languages, create adaptations, summaries or extracts of the Article or other Derivative Works (including, without limitation, the Video) or Collective Works based on all or any portion of the Article and exercise all of the rights set forth in (a) above in such translations, adaptations, summaries, extracts, Derivative Works or Collective Works and(c) to license others to do any or all of the above. The foregoing rights may be exercised in all media and formats, whether now known or hereafter devised, and include the right to make such modifications as are technically necessary to exercise the rights in other media and formats. If the "Open Access" box has been checked in **Item 1** above, JoVE and the Author hereby grant to the public all such rights in the Article as provided in, but subject to all limitations and requirements set forth in, the CRC License.

4. **Retention of Rights in Article.** Notwithstanding the exclusive license granted to JoVE in **Section 3** above, the Author shall, with respect to the Article, retain the non-exclusive right to use all or part of the Article for the non-commercial purpose of giving lectures, presentations or teaching classes, and to post a copy of the Article on the Institution's website or the Author's personal website, in each case provided that a link to the Article on the JoVE website is provided and notice of JoVE's copyright in the Article is included. All non-copyright intellectual property rights in and to the Article, such as patent rights, shall remain with the Author.

5. **Grant of Rights in Video – Standard Access.** This **Section 5** applies if the "Standard Access" box has been checked in **Item 1** above or if no box has been checked in **Item 1** above. In consideration of JoVE agreeing to produce, display or otherwise assist with the Video, the Author hereby acknowledges and agrees that, Subject to **Section 7** below, JoVE is and shall be the sole and exclusive owner of all rights of any nature, including, without limitation, all copyrights, in and to the Video. To the extent that, by law, the Author is deemed, now or at any time in the future, to have any rights of any nature in or to the Video, the Author hereby disclaims all such rights and transfers all such rights to JoVE.

6. **Grant of Rights in Video – Open Access.** This **Section 6** applies only if the "Open Access" box has been checked in **Item 1** above. In consideration of JoVE agreeing to produce, display or otherwise assist with the Video, the Author hereby grants to JoVE, subject to **Section 7** below, the exclusive, royalty-free, perpetual (for the full term of copyright in the Article, including any extensions thereto) license (a) to publish, reproduce, distribute, display and store the Video in all forms, formats and media whether now known or hereafter developed (including without limitation in print, digital and electronic form) throughout the world, (b) to translate the Video into other languages, create adaptations, summaries or extracts of the Video or other Derivative Works or Collective Works based on all or any portion of the Video and exercise all of the rights set forth in (a) above in such translations, adaptations, summaries, extracts, Derivative Works or Collective Works and (c) to license others to do any or all of the above. The foregoing rights may be exercised in all media and formats, whether now known or hereafter devised, and include the right to make such modifications as are technically necessary to exercise the rights in other media and formats. For any Video to which this **Section 6** is applicable, JoVE and the Author hereby grant to the public all such rights in the Video as provided in, but subject to all limitations and requirements set forth in, the CRC License.

7. **Government Employees.** If the Author is a United States government employee and the Article was prepared in the course of his or her duties as a United States government employee, as indicated in **Item 2** above, and any of the licenses or grants granted by the Author hereunder exceed the scope of the 17 U.S.C. 403, then the rights granted hereunder shall be limited to the maximum rights permitted under such statute. In such case, all provisions contained herein that are not in conflict with such statute shall remain in full force and effect, and all provisions contained herein that do so conflict shall be deemed to be amended so as to provide to JoVE the maximum rights permissible within such statute.

8. **Protection of the Work.** The Author(s) authorize JoVE to take steps in the Author(s) name and on their behalf if JoVE believes some third party could be infringing or might infringe the copyright of either the Author's Article and/or Video.

9. **Likeness, Privacy, Personality.** The Author hereby grants JoVE the right to use the Author's name, voice, likeness, picture, photograph, image, biography and performance in any way, commercial or otherwise, in connection with the Materials and the sale, promotion and distribution thereof. The Author hereby waives any and all rights he or she may have, relating to his or her appearance in the Video or otherwise relating to the Materials, under all applicable privacy, likeness, personality or similar laws.

10. **Author Warranties.** The Author represents and warrants that the Article is original, that it has not been published, that the copyright interest is owned by the Author (or, if more than one author is listed at the beginning of this Agreement, by such authors collectively) and has not been assigned, licensed, or otherwise transferred to any other party. The Author represents and warrants that the author(s) listed at the top of this Agreement are the only authors of the Materials. If more than one author is listed at the top of this Agreement and if any such author has not entered into a separate Article and Video License Agreement with JoVE relating to the Materials, the Author represents and warrants that the Author has been authorized by each of the other such authors to execute this Agreement on his or her behalf and to bind him or her with respect to the terms of this Agreement as if each of them had been a party hereto as an Author. The Author warrants that the use, reproduction, distribution, public or private performance or display, and/or modification of all or any portion of the Materials does not and will not violate, infringe and/or misappropriate the patent, trademark, intellectual property or other rights of any third party. The Author represents and warrants that it has and will continue to comply with all government, institutional and other regulations, including, without limitation all institutional, laboratory, hospital, ethical, human and animal treatment, privacy, and all other rules, regulations, laws, procedures or guidelines, applicable to the Materials, and that all research involving human and animal subjects has been approved by the Author's relevant institutional review board.

11. **JoVE Discretion.** If the Author requests the assistance of JoVE in producing the Video in the Author's facility, the Author shall ensure that the presence of JoVE employees, agents or independent contractors is in accordance with the relevant regulations of the Author's institution. If more than one author is listed at the beginning of this Agreement, JoVE may, in its sole

1 Alewife Center #200
Cambridge, MA 02140
tel. 617.945.9051
www.jove.com

ARTICLE AND VIDEO LICENSE AGREEMENT

discretion, elect not take any action with respect to the Article until such time as it has received complete, executed Article and Video License Agreements from each such author. JoVE reserves the right, in its absolute and sole discretion and without giving any reason therefore, to accept or decline any work submitted to JoVE. JoVE and its employees, agents and independent contractors shall have full, unfettered access to the facilities of the Author or of the Author's institution as necessary to make the Video, whether actually published or not. JoVE has sole discretion as to the method of making and publishing the Materials, including, without limitation, to all decisions regarding editing, lighting, filming, timing of publication, if any, length, quality, content and the like.

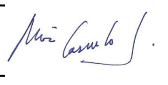
12. **Indemnification.** The Author agrees to indemnify JoVE and/or its successors and assigns from and against any and all claims, costs, and expenses, including attorney's fees, arising out of any breach of any warranty or other representations contained herein. The Author further agrees to indemnify and hold harmless JoVE from and against any and all claims, costs, and expenses, including attorney's fees, resulting from the breach by the Author of any representation or warranty contained herein or from allegations or instances of violation of intellectual property rights, damage to the Author's or the Author's institution's facilities, fraud, libel, defamation, research, equipment, experiments, property damage, personal injury, violations of institutional, laboratory, hospital, ethical, human and animal treatment, privacy or other rules, regulations, laws, procedures or guidelines, liabilities and other losses or damages related in any way to the submission of work to JoVE, making of videos by JoVE, or publication in JoVE or elsewhere by JoVE. The Author shall be responsible for, and shall hold JoVE harmless from, damages caused by lack of sterilization, lack of cleanliness or by contamination due to the making of a video by JoVE its employees, agents or independent contractors. All sterilization, cleanliness or decontamination procedures shall be solely the responsibility of the Author and shall be undertaken at the Author's expense. All indemnifications provided herein shall include JoVE's attorney's fees and costs related to said losses or damages. Such indemnification and holding harmless shall include such losses or damages incurred by, or in connection with, acts or omissions of JoVE, its employees, agents or independent contractors.

13. **Fees.** To cover the cost incurred for publication, JoVE must receive payment before production and publication the Materials. Payment is due in 21 days of invoice. Should the Materials not be published due to an editorial or production decision, these funds will be returned to the Author. Withdrawal by the Author of any submitted Materials after final peer review approval will result in a US$1,200 fee to cover pre-production expenses incurred by JoVE. If payment is not received by the completion of filming, production and publication of the Materials will be suspended until payment is received.

14. **Transfer, Governing Law.** This Agreement may be assigned by JoVE and shall inure to the benefits of any of JoVE's successors and assignees. This Agreement shall be governed and construed by the internal laws of the Commonwealth of Massachusetts without giving effect to any conflict of law provision thereunder. This Agreement may be executed in counterparts, each of which shall be deemed an original, but all of which together shall be deemed to me one and the same agreement. A signed copy of this Agreement delivered by facsimile, e-mail or other means of electronic transmission shall be deemed to have the same legal effect as delivery of an original signed copy of this Agreement.

A signed copy of this document must be sent with all new submissions. Only one Agreement is required per submission.

CORRESPONDING AUTHOR

Name:	María Consuelo Sáiz Manzanares
Department:	Departamento de Ciencias de la Salud (Health Sciences)
Institution:	Universidad de Burgos
Title:	Measuring the Functional Abilities of Children with Observational Methods and Computer Tools
Signature:	 Firmado digitalmente por SAIZ MANZANARES MARIA CONSUELO - 13102904B Nombre de reconocimiento (DN): c=ES, serialNumber=IDCES-13102904B, givenName=MARIA CONSUELO, sn=SAIZ MANZANARES, cn=SAIZ MANZANARES MARIA CONSUELO - 13102904B Fecha: 2019.12.21 17:21:44 +01'00'
Date:	21 of December 2019

Please submit a **signed** and **dated** copy of this license by one of the following three methods:

1. Upload an electronic version on the JoVE submission site
2. Fax the document to +1.866.381.2236
3. Mail the document to JoVE / Attn: JoVE Editorial / 1 Alewife Center #200 / Cambridge, MA 02140