ChildCIdb_v2: A Longitudinal Database for Children-Computer Interaction on Mobile Devices

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Abstract

Children are increasingly exposed to mobile devices on a daily basis. This opens the doors to the proposal of novel methods to automatically quantify the correct motor and cognitive development of children through the use of mobile devices. This study presents ChildCIdb_v2, a longitudinal database for Child-Computer Interaction (CCI) on mobile devices. ChildCIdb_v2 contains 615 different children from 18 months to 8 years old, and 6 different acquisition sessions carried out since 2020. In total, there are over 2.1K children acquisitions using both a stylus or the finger to interact with the touch screen. Preliminary experiments confirm the potential of ChildCIdb_v2 to conduct longitudinal analyses of the children, for example, early detection of children with motor/cognitive disorders.

Keywords

child-computer interaction, childcidb, longitudinal analysis, e-health, e-learning

1. Introduction

The exposure of children aged 0-8 years to mobile devices has increased dramatically in recent decades (11 times from 2011 to 2020 [1]) due to technological innovation [2]. They are growing up in environments overloaded with multiple digital technologies (e.g., smartphones, tablets, smart TVs, smartwatches, etc.) [3, 4].

Despite this technological evolution, the assessment of the correct motor and cognitive development of children is still evaluated using traditional approaches that are manual, time-consuming, and provide qualitative results that are difficult to interpret. This is one of the main motivations of our ChildCI research project [5]: the proposal of automatic methods to quantify the motor and cognitive development of the children through the interaction with mobile devices, using both the stylus [6, 7, 8] and the finger [9, 10].

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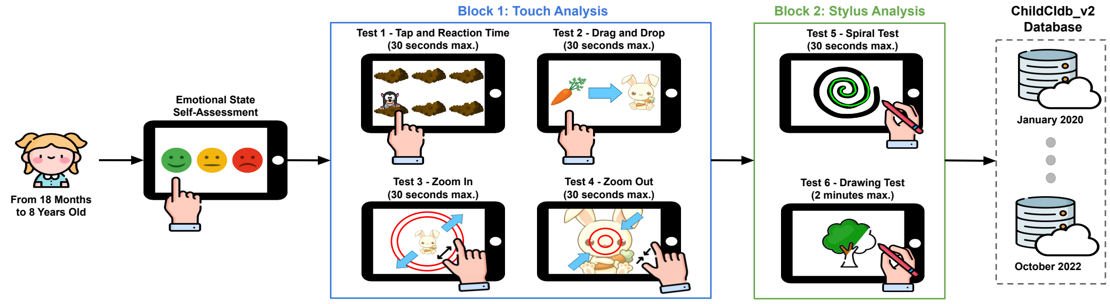

Figure 1: Graphical representation of the different interfaces designed in ChildCIdb_v2, which comprises 6 different acquisition sessions since January 2020. Two main acquisition blocks are considered: *i)* touch, and *ii)* stylus.

This paper presents ChildCIdb_v2 database, a longitudinal extension of the first release of ChildCIdb_v1[1][5]. To the best of our knowledge, this is the largest publicly available database to date for research in CCI. In particular, ChildCIdb_v2 contains 6 different acquisition sessions carried out since 2020 in collaboration with the school GSD Las Suertes in Madrid, Spain. Children aged 18 months to 8 years are acquired while interacting with a tablet device using finger and stylus tools. According to the Spanish education system, children are grouped into 7 different educational levels (Groups 2 to 8). During the acquisition process, children perform 6 different tests grouped into 2 main blocks: *i)* touch, and *ii)* stylus. Fig. 1 provides a graphical representation of the acquisition. Each test requires different motor and cognitive skills to be completed correctly within a time range. Next, we briefly describe each of the tests [5]:

- *Block 1: Touch Analysis*
  - **Test 1 - Tap and Reaction Time:** there are 6 burrows and 1 mole. Children must tap the mole using only one finger. Then it disappears and reappears in another burrow up to 4 times (30 seconds max).
  - **Test 2 - Drag and Drop:** there is a carrot and a rabbit on the screen. Children must tap the carrot and swipe it to the rabbit using only one finger (30 seconds max).
  - **Test 3 - Zoom In:** there is a small rabbit and 2 circles of different sizes. Children must enlarge the rabbit and put it between circles using 2 fingers (30 seconds max).
  - **Test 4 - Zoom Out:** it is very similar to Test 3, but this time the rabbit must be reduced. 2 fingers are needed again (30 seconds max).
- *Block 2: Stylus Analysis*
  - **Test 5 - Spiral Test:** using a pen stylus, children must go across the inner part of the black spiral, from the central to the outer part (30 seconds max).
  - **Test 6 - Drawing Test:** the outline of a tree appears on the screen. Children must color the whole tree using a pen stylus (2 minutes max).

In addition, other children's metadata is also collected such as emotional state, previous experience with mobile devices, prematurity ($<$ 37 weeks gestation), attention deficit/hyperactivity disorder (ADHD), date of birth, gender, handedness, and academic grades.

[1] https://github.com/BiDAlab/ChildCIdb_v1

2. ChildCIdb_v2: Longitudinal Database

ChildCIdb_v2 contains data from 615 different children in total. In particular, 6 data acquisitions have been carried out in the last 4 academic years, comprising over 2.1K children's sessions and over 12.6K children's interactions with mobile devices (each session comprises 6 tests). The same children have been acquired along time until they reach the highest educational level (Group 8). In addition, new children from the lowest educational levels were also captured in each acquisition (Groups 2 to 4). Table 1 describes the total number of children collected for each age group and data acquisition, as well as the gender information (about 50% of the children are male/female).

Table 1

Statistics of each acquisition of ChildCIdb_v2 regarding the number of children and gender information.

Academic Year	Acquisition	Group 2 (18M-2Y)	Group 3 (2Y-3Y)	Group 4 (3Y-4Y)	Group 5 (4Y-5Y)	Group 6 (5Y-6Y)	Group 7 (6Y-7Y)	Group 8 (7Y-8Y)	# Children by Acquisition	% Gender (Male | Female)
2019/20	1st Acquisition (Jan 2020)	18	36	50	66	93	77	98	438	50.0% | 50.0%
2020/21	2nd Acquisition (May 2021)	40	18	36	51	67	89	75	376	51.3% | 48.7%
2021/22	3rd Acquisition (Oct 2021)	14	45	18	34	49	67	88	315	52.4% | 47.6%
2021/22	4th Acquisition (Mar 2022)	30	45	17	34	49	66	87	328	52.4% | 47.6%
2021/22	5th Acquisition (Jun 2022)	34	44	18	34	48	65	85	328	53.4% | 46.6%
2022/23	6th Acquisition (Oct 2022)	5	59	101	18	34	49	65	331	52.3% | 47.7%

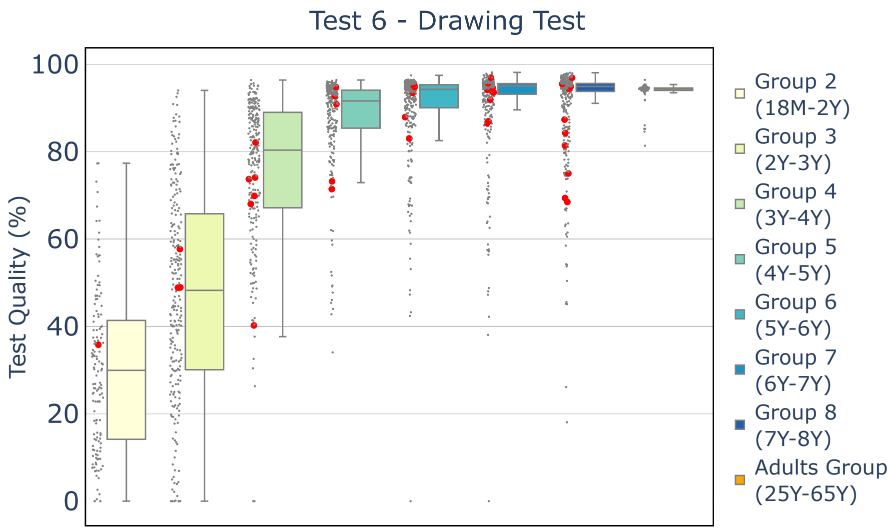

Figure 2: Box plot of test quality (%) obtained in Test 6 (Drawing Test) for each educational level with respect to the adults group. Red points refer to children with developmental disorders. The line in the center of the box represents the median value. Lower and upper ends of the box represent the Q1 and Q3 quartiles, respectively. Whiskers represent the outliers.

3. Preliminary Experiments

In [5, 11] we performed the first experiments over a previous version of ChildCIdb. We demonstrated the high discriminative power for the task of age group detection (over 93% accuracy), and the inherent applicability of the tests to other research problems around e-Learning [12, 13] and e-Health [14, 15].

We provide next a preliminary experiment using ChildCIdb_v2. Fig. 2 shows the test quality (%) obtained for Test 6 (Drawing Test) for each age group against a control group of 70 adults with all their motor and cognitive skills fully developed. The more colored the tree is, the higher the test quality will be. Coloring out is penalized.

As can be seen in Fig. 2, the higher the level group is, the higher the test quality is, showing better motor and cognitive skills. In general, children at higher educational levels (Groups 7 and 8) obtain a test quality very similar to that of an adult. However, in the lower groups, where children still have to develop the motor and cognitive skills needed to complete Test 6 correctly, the test quality is lower and with higher variability.

To conclude the paper, ChildCIdb_v2 enables longitudinal studies to advance in: *i)* measuring the motor and cognitive development of children through the use of mobile devices to detect delays or difficulties during the development, enabling early interventions [16, 17]; and *ii)* finding relationships between children's interaction with mobile devices and other metadata stored in ChildCIdb (academic grades, prematurity, etc.), among others.

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References

[1] V. Rideout, M. B. Robb, The Common Sense Census: Media Use By Kids Age Zero to Eight, Common Sense Media, San Francisco, SF, 2020.

[2] J. Radesky, H. Weeks, R. Ball, A. Schaller, S. Yeo, J. Durnez, M. Tamayo-Rios, M. Epstein, H. Kirkorian, S. Coyne, R. Barr, Young Children's Use of Smartphones and Tablets, Pediatrics 146 (2020). doi:https://doi.org/10.1542/peds.2019-3518.

[3] A. N. Antle, J. P. Hourcade, Research in Child–Computer Interaction: Provocations and Envisioning Future Directions, International Journal of Child-Computer Interaction (2021) 100374. doi:https://doi.org/10.1016/j.ijcci.2021.100374.

[4] H. K. Kabali, M. M. Irigoyen, R. Nunez-Davis, J. G. Budacki, S. H. Mohanty, K. P. Leister,

J. Bonner, Robert L., Exposure and Use of Mobile Media Devices by Young Children, Pediatrics 136 (2015) 1044–1050. doi:https://doi.org/10.1542/peds.2015-2151.

[5] R. Tolosana, J. C. Ruiz-Garcia, R. Vera-Rodriguez, J. Herreros-Rodriguez, S. Romero-Tapiador, A. Morales, J. Fierrez, Child-Computer Interaction with Mobile Devices: Recent Works, New Dataset, and Age Detection, IEEE Transactions on Emerging Topics in Computing (2022) 1–1. doi:https://doi.org/10.1109/TETC.2022.3150836.

[6] C. Rémi, J. Vaillant, R. Plamondon, L. Prevost, T. Duval, Exploring the Kinematic Dimensions of Kindergarten Children's Scribbles, in: Proceedings of the 17th Biennial Conference of the International Graphonomics Society, International Graphonomics Society (IGS) and Université des Antilles (UAG), Pointe-à-Pitre, Guadeloupe, 2015, pp. 79–82.

[7] C. Gonzalez-Garcia, R. Tolosana, R. Vera-Rodriguez, J. Fierrez, J. Ortega-Garcia, Introduction to Presentation Attacks in Signature Biometrics and Recent Advances, Handbook of Biometric Anti-Spoofing: Presentation Attack Detection and Vulnerability Assessment (2023) Sébastien Marcel, Julian Fierrez, and Nicholas Evans (Eds.). Springer Nature Singapore, 447–466. doi:https://doi.org/10.1007/978-981-19-5288-3_16.

[8] R. Tolosana, R. Vera-Rodriguez, R. Guest, J. Fierrez, J. Ortega-Garcia, Exploiting Complexity in Pen- and Touch-Based Signature Biometrics, International Journal on Document Analysis and Recognition (IJDAR) 23 (2020) 129–141. doi:https://doi.org/10.1007/s10032-020-00351-3.

[9] R. Tolosana, R. Vera-Rodriguez, J. Fierrez, J. Ortega-Garcia, BioTouchPass2: Touchscreen Password Biometrics Using Time-Aligned Recurrent Neural Networks, IEEE Transactions on Information Forensics and Security 15 (2020) 2616–2628. doi:https://doi.org/10.1109/TIFS.2020.2973832.

[10] G. Stragapede, R. Vera-Rodriguez, R. Tolosana, A. Morales, BehavePassDB: Public Database for Mobile Behavioral Biometrics and Benchmark Evaluation, Pattern Recognition 134 (2023) 109089. doi:https://doi.org/10.1016/j.patcog.2022.109089.

[11] J. C. Ruiz-Garcia, R. Tolosana, R. Vera-Rodriguez, J. Fierrez, J. Herreros-Rodriguez, ChildCI Framework: Analysis of Motor and Cognitive Development in Children-Computer Interaction for Age Detection, 2022. arXiv:2204.04236.

[12] R. Daza, A. Morales, R. Tolosana, L. F. Gomez, J. Fierrez, J. Ortega-Garcia, edBB-Demo: Biometrics and Behavior Analysis for Online Educational Platforms, in: Proceedings of AAAI Conf. on Artificial Intelligence (AAAI), 2023.

[13] R. Daza, L. F. Gomez, A. Morales, J. Fierrez, R. Tolosana, R. Cobos, J. Ortega-Garcia, MATT: Multimodal Attention Level Estimation for e-learning Platforms, in: Proceedings of AAAI Conf. on Artificial Intelligence Workshops (AAAIw), 2023.

[14] P. Melzi, R. Tolosana, A. Cecconi, A. Sanz-Garcia, G. J. Ortega, L. J. Jimenez-Borreguero, R. Vera-Rodriguez, Analyzing Artificial Intelligence Systems for the Prediction of Atrial Fibrillation from Sinus-Rhythm ECGs Including Demographics and Feature Visualization, Scientific Reports 11 (2021) 22786. doi:https://doi.org/10.1038/s41598-021-02179-1.

[15] S. Romero-Tapiador, B. Lacruz-Pleguezuelos, R. Tolosana, G. Freixer, R. Daza, C. M. Fernández-Díaz, E. Aguilar-Aguilar, J. Fernández-Cabezas, S. Cruz Gil, S. Molina-Arranz, M. C. Crespo, T. Laguna-Lobo, L. J. Marcos-Zambrano, R. Vera-Rodriguez, J. Fierrez, A. Ramírez de Molina, J. Ortega-Garcia, I. Espinosa-Salinas, A. Morales, E. Carrillo de

Santa Pau, AI4FoodDB: A Database for Personalized e-Health Nutrition and Lifestyle through Wearable Devices and Artificial Intelligence, Database: The Journal of Biological Databases and Curation (2023).

[16] A. Acien, A. Morales, R. Vera-Rodriguez, J. Fierrez, I. Mondesire-Crump, T. Arroyo-Gallego, Detection of Mental Fatigue in the General Population: Feasibility Study of Keystroke Dynamics as a Real-world Biomarker, JMIR Biomed Engineering 7 (2022) e41003. doi:https://doi.org/10.2196/41003.

[17] L. F. Gomez, A. Morales, J. Fierrez, J. R. Orozco-Arroyave, Exploring Facial Expressions and Action Unit Domains for Parkinson Detection, PLOS ONE 18 (2023) 1–25. doi:https://doi.org/10.1371/journal.pone.0281248.