Objectivity in clinical diagnosis of ADHD by means of AULA virtual reality based neuropsychological test: Initial findings

Unai Diaz-Orueta[1], Manuel A. Fernández-Fernández[2], Gema Climent[1],
[1]Nesplora, Technology & Behavior, Donostia-San Sebastian, Spain
[2]Instituto Andaluz de Neurología Pediátrica (INANP), Sevilla, Spain
Contact: Dr. Unai Diaz-Orueta, udiaz@nesplora.com. Nesplora, Technology & Behavior Paseo de Mikeletegi, 54, Of. 13, 20009 Donostia-San Sebastian, Spain

Background: Neuropsychological evaluation in ADHD

- ADHD diagnosis is essentially **clinical**.
- However, quantification of behaviours that configure the disorder is important for the diagnosis and follow-up after eventual treatments are put in place (Crespo-Eguílaz & Narbona, 2013).
- **Neuropsychological evaluation has progressively become a part of the protocol** for an efficient approach to the understanding of this disorder (Holmes et al., 2010).
- Criticism performed by Gualtieri y Johnson (2005) to the **lack of ecological validity of traditional batteries** opens the door to new ways of assessment: computerized tests.
- **Increasing evidence of the utility of VR to test attention processes in ADHD** (Bioulac et al., 2012; Diaz-Orueta et al., 2014; Iriarte, Diaz-Orueta et al., 2012; Rizzo et al., 2000; Rizzo et al., 2006).

Objective

- **Use AULA VR neurosychological test to differentiate between clinical presentations in ADHD (subtypes)**
- AULA measures **attention processes** and **motor activity** in children between 6 and 16 years-old on a CPT based paradigm with different tasks and distracting conditions (Climent & Banterla, 2011).
- AULA includes **visual and auditory stimuli**.
- Visual, auditory and mixed **distractors** try to interfere in child's performance.

AULA is composed by **2 main exercises**:
- A **No-X** paradigm based exercise: "*Press the button when you DO NOT see or hear apple*".
- An **X** paradigm based exercise: "*Press the button whenever you DO see or hear seven*".

Sample and Method

- **124 children** (97 boys and 27 girls)
- Mean age = 9.78 years-old (SD = 2.82, age range = 6-16 years old)
- Recruited from a paediatric neurology institute in Southern Spain
- 49 were **clinically diagnosed of ADHD** inattentive subtype (I) and 75 of ADHD combined subtype (C).
- All children were administered AULA test
- All parents (and children who were older than 12) signed an informed consent form to give acceptance to their participation in the study.
- Due to lack of normality of studied variables, a Mann Whitney U test was applied to analyse these differences (*m* = mean ranks).

Measures

AULA scores (Variables)	Description
Omission errors (inattention)	Patient does NOT press the button when he should.
Commission errors (impulsivity)	Patient presses the button when he should NOT
Reaction time (processing speed)	Measured for correct answers and commission errors
Variability (sd) in reaction time (sustained attention)	Changes in reaction time patterns during the test
Motor activity (hyperactivity)	Head movement, tracked with a movement sensor placed in the 3D glasses
All previous scores include: Total scores, scores comparing No-X vs X task, scores comparing visual vs. auditory performance (divided attention), scores when distractors are present vs. when distractors are absent (interference of external distractors).	
Quality of attention focus (quality of attention, interference of internal distractors)	Number of errors performed by the subject when he/she has the blackboard in his/her viewing angle.

Results

	Clinical presentation	*m*	U	Z	*p*
Total commissions	I	53.62	1402.5	-2.226	.026
	C	68.30			
Total RT correct answers (sd)	I	53.76	14090	-2.19	.029
	C	68.21			
Total Activity	I	47.72	1113.5	-3.701	.000
	C	72.15			
Total Dev. from focus	I	49.51	12010	-3.352	.001
	C	70.99			
Visual RT correct answers	I	53.04	1374	-2.369	.018
	C	68.68			
Visual RT correct answers (sd)	I	50.78	1263	-2.936	.003
	C	70.16			
Auditory Omissions	I	53.87	1414.5	-2.167	.030
	C	68.14			
Auditory Commissions	I	50.64	1256.5	-2.984	.003
	C	70.25			
With distractors: Commissions	I	53.90	1416	-2.165	.030
	C	68.12			
With distractors: Activity	I	48.86	1169	-3.417	.001
	C	71.41			
With distractors: Dev. from focus	I	50.63	1256	-3.128	.002
	C	70.25			
Without distractors: RT correct (sd)	I	53.35	1389	-2.292	.022
	C	68.48			
Without distractors: Activity	I	47.54	1104.5	-3.747	.000
	C	72.27			
Without distractors: Dev. from focus	I	49.53	1202	-3.383	.001
	C	70.97			
No-X: RT correct answers (sd)	I	53.18	1381	-2.333	.020
	C	68.59			
No-X: Activity	I	48.88	1170	-3.412	.001
	C	71.40			
No-X: Dev. from focus	I	51.35	1291	-2.940	.003
	C	69.79			
X: Omissions	I	51.54	1300.5	-2.753	.006
	C	69.66			
X: Commissions	I	52.09	1327.5	-2.634	.008
	C	69.30			
X: Activity	I	47.39	1097	-3.785	.000
	C	72.37			
X: Dev. from focus	I	49.86	1218	-3.332	.001
	C	70.76			
Errors while watching the blackboard	I	50.74	1261.5	-2.954	.003
	C	70.18			

Discussion of results

- Statistically significant differences were obtained, showing a **worse performance for ADHD combined-type ch**ildren than for inattentive **in all presented variables**.
- General indexes of AULA: significant differences were found in total commissions and sustained attention but more prominently in motor activity and deviation from the focus.
- **Differences in motor activity and deviation from the focus** are the **main indicator of worse performance for combined-typ echildren** in all testing conditions (with and without distractors, No-X task, X tasks).
- Combined-type children also show (1) worse visual processing speed and sustained attention and (2) more inattention and impulsivity when faced with auditory stimuli.
- Inattention and impulsivity differences are more evident when the task

Conclusion and future research

- AULA VR test may provide objective information and increase the accuracy of differential diagnosis between ADHD clinical presentations, especially by measuring motor activity and deviation from the focus, as a low performance in these measures may be more representative of the hyperactivity component.
- Future studies will be needed to increase the accuracy of AULA and establish cut points to differentiate more accurately between clinical presentations and non-clinical performance.

REFERENCES
1. Bioulac, S., Lallemand, S., Rizzo, A., Philip, P., Fabrigoule, C., & Bouvard, M. P. (2012). Impact of time on task on ADHD patient's performances in a virtual classroom. *European Journal of Paediatric Neurology.* doi:10.1016/j.ejpn.2012.01.006 Advance online publication.
2. Climent, G., & Banterla, F. (2011). AULA, ecological evaluation of attentional processes [Book in Spanish]. San Sebastian: Nesplora.
3. Diaz-Orueta, U., Garcia-López, C., Crespo-Eguílaz, N., Sánchez-Carpintero, R., Climent, G. & Narbona, J. (2013): AULA virtual reality test as an attention measure: Convergent validity with Conners. Continuous Performance Test, Child Neuropsychology: A Journal on Normal and Abnormal Development in Childhood and Adolescence, DOI:10.1080/09297049.2013.792332 .
4. Iriarte, Y., Diaz-Orueta, U., Cueto, E., Irazustabarrena, P., Banterla, F., & Climent, G. (2012, in press). AULA—Advanced Virtual Reality Tool for the Assessment of Attention: Normative Study in Spain. *Journal of Attention Disorders.* DOI: 10.1177/1087054712465335
5. Rizzo, A. A., Bowerly, T., Buckwalter, J. G., Limchuk, D., Mitura, R., & Parsons, T. D. (2006). A virtual reality scenario for all seasons: The virtual classroom. *CNS Spectrums, 11*(1), 35–44.
6. Rizzo, A. A., Buckwalter, J. G., Bowerly, T., Van der Zaag, C., Humphrey, L., Neumann, U., . . . Sisemore, D. (2000). The virtual classroom: A virtual reality environment for the assessment and rehabilitation of attention deficits. *Cyberpsychology & Behavior, 3*(3), 483–499.