The approach of simple mechanical phenomena in the field of Autism Spectrum Disorders

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ABSTRACT
This paper examines the physics ability of pupils with autism spectrum disorder. For this reason a folk Physics test was given to 19 adolescents with high functioning autism spectrum disorder and 55 adolescents with typical development. Results showed that adolescents with autism scored statistical higher compared to those of typical development. It seems therefore that pupils with autism have intact their folk physics ability. Hence, it is time for science education researchers to turn their attention in exploring how pupils with autism could be taught and learn physics in the most appropriate way.

KEYWORDS
Autism spectrum disorder, science education, folk physics test

RÉSUMÉ
Cet article examine la capacité en physique d'élèves atteints de trouble global du développement. Pour cette raison un test de physique a été donné à 19 adolescents ayant un trouble global du développement de haut niveau et à 55 adolescents ayant un développement typique. Les résultats ont montré que les adolescents ayant un trouble global du développement ont eu statistiquement un score plus élève comparés à ceux ayant un développement typique. Il parait ainsi que les élèves autistes ont leur capacité en physique intacte. Par conséquent, il est temps pour les chercheurs de l'enseignement des sciences de tourner leur attention vers l'exploration de comment les élèves autistes pourraient recevoir l'enseignement et apprendre la physique de manière plus appropriée.

MOTS-CLÉS
Trouble global du développement, enseignement des sciences, test en physique

THEORETICAL FRAMEWORK

Science Education and Special Needs

It is well known in the educational scientific community that children have their own ideas about a number of natural phenomena, in advance of their schooling. Indeed many researches, which have been conducted in the last decades, explicitly show that children have informal ideas about everyday phenomena such as gravity, electricity and optics, prior to teaching (Kada & Ravanis 2016; Rodriguez & Castro, 2016; Serhane, Zeghdaoui & Debiach, 2017; Ravanis, 2018). The origins of these ideas, which are usually called misconceptions or

alternative conceptions, vary. The prevailing culture, ideas from the media and the folklore of each country play a crucial role in student's alternative conceptions (Driver, Guesne & Tiberghien, 1985). What is noteworthy here is that these mini-theories are not idiosyncratic. Far from it, they constitute a coherent model in children's minds, which enables them to cope with the world and make predictions. As a result, a conflict often exists in a child's mind between their intuitive ideas and the scientific ideas that are taught in school. According to the constructivist view of learning, science learning involves making links between existing informal ideas and the scientific point of view (Ravanis, 2005). Indeed, 'if the ideas held by the students are to be taken into account, teaching cannot simply be viewed as the telling or giving of knowledge to students (Brook et al., 1984, p. 22). So the teacher should be aware of the alternative conceptions that pupils have about a natural phenomenon and be ready to adjust their teaching in response to these conceptions. On the other hand, the students should be ready to play an active intellectual role in the learning process and accommodate the new ideas (Remountaki, Fragkiadaki & Ravanis, 2017).

Nevertheless, while a number of researchers have tried to identify alternative conceptions of typical development students, this has not been the case for students falling within the scope of special education. Indeed, few researchers have tried to explore science education in the wilderness of special education spectrum (Vavougios & Panteliadou, 2006; Stavroussi, Papalexopoulos & Vavougios, 2010; Brigham, Scruggs & Mastropieri, 2011; Maleza & Kalogiannakis, 2012; Kaliampos et al., 2017). This happens despite the fact that studies from special education field give us strong evidences that specific categories of those pupils may have extreme potential in excelling in science domains such as Physics. Therefore it is worthwhile to try to teach physics to them in a way that is understandable from their way of thinking. One category of those pupils is definitely students with high functioning autism spectrum disorders (HFASD).

Autism Spectrum Disorder

Autism is one of the most severe neurodevelopment disorders that fit into special education. Strong evidences of researches the last decade support the view that autism has genetic etiology even if it has not proven until yet (Cantio et al., 2016). Due to the fact that abilities of each person with autism vary according to both age and mental state, scientists use the expression "autism spectrum", thus including a multitude of cases with similar characteristics. At one end of the spectrum stands Kanner syndrome which includes low-functionality individuals while on the other exist Asperger syndrome with highly functional individuals (Ring et al., 2008; Mavropoulou, 2011). According to DSM-5, individuals in this spectrum are characterized by deficits in two key areas 1) social communication and interaction and 2) restricted repetitive behavior, interests, and activities (American Psychiatric Association, 2013).

With regard to social communication and interaction, there is an extremely slow and divergent development of sociability, especially interpersonal contact. Pupils have particular difficulties in developing friendly relationships and working smoothly with their peers. In their attempt to interact with others, they use a very paradoxical approach, which is often misunderstood and perceived as annoying. As a result, they are confronted with social exclusion and experience isolation (Klin, 2006). Moreover, the inability of children in the autism spectrum to understand social rules such as the fact that to shop in a school canteen one must first wait in the queue makes them appear in the eyes of other children unfamiliar and therefore disagreeable.

In addition, pupils in the autistic spectrum are particularly vulnerable to understand the social use of language. They attribute to each word exclusively its literal meaning and thus often block when they come across to expressions such as 'yesterday it was raining dogs and

cats' or 'he is a fish out of water' (Gerland, 2000). Moreover, the concepts of joke and sarcasm are unknown to them, so many times they misinterpret what is going on in a conversation and inevitably feel afflicted or angry (DfES, 2004). Finally, the difficulties they face on understanding the body language of another person set them in a difficult condition. Indeed, the complete disconnection between one's words and the movements of the body that accompany his or her words, such as an obvious smile or an aggressive gram, make the decoding of meanings a particularly difficult procedure for pupils with autism (Gerland, 2000).

As for restricted repetitive behavior, interests, and activities, the lack of imagination and the inelasticity in their thinking lead them to strange and ritualistic behaviors where routine maintenance plays a leading role (Karantanos & Francis, 2014). Their difficulty in coping with any change in their routine makes their daily routines very difficult, as small or big changes in everyday routine are known to be inevitable. In addition, the rigidity in their thinking has the effect that autistic children have a problem in generalizing and drawing useful conclusions (DfES, 2004).

According to DSM-5, part of the recurrent and stereotypical behavior of autistic individuals is also hyper-sensitivity or hypersensitivity to various sensory stimuli (American Psychiatric Association 2013). Thus, on the one hand, they can be overcome with intense anxiety and react excessively to some intense sound, smell or light while on the other they may not react to the most common stimuli such as listening to their name (Iarocci & McDonald, 2006). Klin (2006) refers to the difficulties faced by people with autism in sensory processing and notes that children with autism often have a particular sensitivity in very common sounds such as the barking of a dog or the sound of a vacuum cleaner. Also in intense light and touch, either it is a strong embrace or a simple handshake.

Autism and knowledge of Physics

Judging from the above, it can be concluded that autism is a syndrome which creates a multitude of difficulties for individuals who fit into it. Nevertheless, surveys of recent years have shown that people in the autistic spectrum have also some islands of abilities; these are remarkable skills in specific fields (Shah & Frith, 1993). One of these areas is natural sciences and specifically physics. Both clinical/anecdotal evidences and experimental studies converge on the above mentioned statement. As for clinical/anecdotal evidences, it is a fact that the majority of pupils with autism spectrum disorders are fascinated with machines such as electricity pylons, washing machines, train, planes etc (Baron-Cohen et al., 2001). These people get obsessed with the underlying mechanism of the machines and try to understand and explain its way of working (Subiaul et al., 2004).

With regard to experimental studies, Baron-Cohen et al. (2001) constructed a Folk Physics Test consisted of 20 questions in multiple choice format. The test was based on the physical intuition of the students and comprised subjects inspired by everyday life and the cause-effect relationship that governs the natural world. A number of pulleys, gears, and levels appeared in these questions and participants had to depict the correct answer each time. The results of the test showed that pupils with autism spectrum disorder scored higher compared to normally developing pupils (Baron-Cohen et al., 2001). Replica studies with the above mentioned test showed that individuals with autism have their folk physics intact or even superior compared to typical development pupils (Krajmer et al., 2010; Paganini & Gaido, 2013).

This paper tries to answer the following research question: How is folk physics of individuals with autism compared to that of typical development individuals? Is it intact or it deviates from the normal population?

METHODOLOGICAL FRAMEWORK

The sample

To address this research question an experimental investigation was conducted with 19 adolescents with high functioning autism spectrum disorder (age range: 12-16 yrs) and 55 adolescent with typical development (age range: 12 to 16 yrs) matched on sex and non verbal mental age. All subjects with high functioning autism spectrum disorder have been diagnosed of meeting criteria for autism either from an official Diagnostic and Support Centre of national ministry of education or from a Greek public hospital. The tool used was Baron-Cohen's et al. (2001) Folk Physics Test which was translated to Greek using forward-backward translation.

The overview of the analytic procedure

First of all, the researcher submitted an application and obtained a license from the Educational Policy Institute (IEP) to enter specific schools of the city of Patras to carry out his research. Having done this, the researcher conducted the headmaster/headmistress of the schools to arrange the exact day and hour of visiting the school. Typical development students who were to take part into the research, after a small discussion with the researcher, were given to complete the test. The researcher was sitting near each student and was offering positive feedback to him when it was necessary. At the end the researcher thanked the student and was preparing to meet the next one. As for the pupils with high functioning autism spectrum disorder, they were recruited either from national public schools were they received special inclusive treatment or from private special education centers. The procedure for them was exactly the same, as it was described above. For all cases, students' participation in the research had been ensured with the written consent of the parent by signing a suitable form.

RESULTS

The analysis of our data showed that the responses given by adolescents with high functioning autism spectrum disorder were generally similar to the responses obtained from the adolescents with typical development, although there were noticeable differences in specific questions (Table 1).

TABLE 1

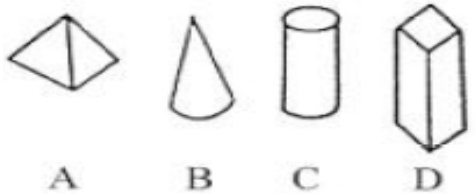
Percentage of adolescents with high-functioning autism spectrum disorder (ASD) and adolescents with typical development (TD) on sampling questions of Folk Physics Test

	Question 5		**Question 6**		**Question 8**		**Question 9**	
	ASD	***TD***	***ASD***	***TD***	***ASD***	***TD***	***ASD***	***TD***
a	6	15	88	82	16	11	10	24
b	0	7	6	7	6	13	84	65
c	68	35	6	2	41	45	6	11
d	26	43	0	9	21	26	-	-
e	-	-	-	-	16	5	-	-

So, for example in Question 6 four blocks were depicted to the participants who in turn had to find out which one is the most difficult to be pushed over (Figure 1). The vast majority of both groups, with almost parallel percentages of 88% and 82% respectively, selected the pyramid as the correct answer. Moreover, they gave answers almost at the same rates to other

objects; that is 6% and 7% to the cone, 6% and 2% to the cylinder and 0% and 9% to the rectangle.

FIGURE 1



Question 6: If each block weighs the same, which one will be most difficult to push over?

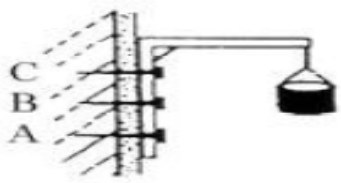
Moreover, Question 8 portrayed a peg in five different directions and participants had to find which direction is likely to give a tent the best hold in soft ground (Figure 2). Again, both adolescents with high functioning autism spectrum disorder and adolescents with typical development pointed out the correct answer (the 4th direction) at almost the same rate, 21% and 26 % respectively. In addition, the most popular answer for both groups where the peg placed vertical (the 3rd direction); answer that was given at almost the same rates of 41% and 45% respectively.

FIGURE 2

Question 8: Which tent peg will give the best hold in soft ground?

Nevertheless, there were questions were adolescents with high functioning autism spectrum disorder seemed to perform better than their peers of typical development. An exemplar paradigm was Question 5, were participants had to indicate which nail is most likely to pull out of the wall (Figure 3). Here, the group of autism achieved a higher performance, pointing out the correct answer (C) at rate of 68%. On the other hand, only 1/3 of adolescents with typical development found the correct answer. It seems that pupils with autism had a far better understanding of this folk physics questions compared to pupils with typical development.

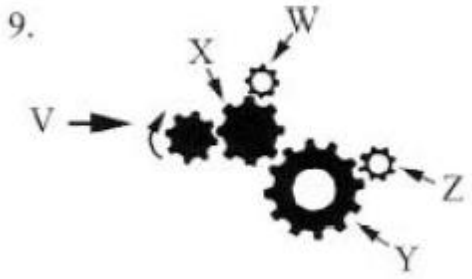
FIGURE 3



Question 5: Which nail is most likely to pull out of the wall?

Finally, adolescents with high functioning autism spectrum disorder performed better in Question 9 were a highly complex system of gear wheels of different sizes was depicted to the participants who in turn had to point out which gear wheel goes in the same direction as the driver (Figure 4). This question undoubtedly requires a good understanding of how each gear interacts with each other and our results showed that the members of the group of pupils with autism had this ability to a greater extent than their peers of typical development. In particular, 84% of adolescents with autism indicated the correct answer (gear wheel Y) in contrast to 65% of adolescents with typical development.

FIGURE 4



Question 9: Which gear wheel goes in the same direction as the driver V?

In addition, data was analyzed through the usage of Statistical Package for Social Sciences. Specifically, a T-test analysis was conducted to compare the overall scores on Folk Physics Test of the two study groups. Results showed that there was a statistical difference $t(72)=2.357$, $p=0.021$ between the scores of adolescents with high functioning autism spectrum disorder ($M=9.84$, $SD=1.803$) and with typical development($M=8.49$, $SD=2.260$). Therefore, it can be concluded that pupils with high functioning autism spectrum disorder have their folk physics superior compared to pupils with typical development.

DISCUSSION

Science education has focused its attention merely in exploring and investigating alternative ideas of students with typical development in a number of science domains such as electricity, magnetism, gravity and matter of state. Nevertheless, as it was stated above, just a few studies have tried to look into ideas of pupils with learning disabilities and special education needs. This happens despite the fact that research evidences support the view that specific categories of these pupils may have an intact or even superior understanding of physics.

The present study examined physics understanding of pupils with autism. Results showed that adolescents with high functioning autism spectrum disorder scored higher in Folk Physics test compared to those of adolescents with typical development. This research finding is in line with previous researches which have studied the performance of students with autism in physics.

Undoubtedly, further research should be conducted to gain a deeper understanding on how pupils with autism comprehend physics. Specifically, researchers should try to design studies to explore alternative ideas of students with autism and other learning disabilities. This will help science educators to built appropriate teaching interventions based on constructivism theory that are going to meet the special needs of those students.

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