J Autism Dev Disord
DOI 10.1007/s10803-017-3031-6

BRIEF REPORT

Brief Report: Testing the Impairment of Initiation Processes Hypothesis in Autism Spectrum Disorder

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Abstract In the present study we aim at providing further evidences for the validity of an initiation processes impairment in autism spectrum disorder (ASD). We applied different verbal fluency tasks designed to decrease or enhance this limitation. A group of high-functioning individuals with ASD and a group of typically developed individuals matched for -age, -IQ and -education, were tested in three verbal fluency tasks. In task 1, we replicated previous findings of an initiation impairment. In tasks 2 and 3, with simple manipulations, we observed that the differences between the groups were respectively eliminated or enhanced. We have not only provided further evidence of impairments in the initiation of a response, but we remarkably show how to circumvent them.

Keywords Executive system · Response initiation · Autism spectrum disorder · Verbal fluency

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Introduction

Response initiation is a key function of the executive system (Shallice and Burgess 1991). Despite the fact, that executive dysfunction has been put forward as a major hypothesis in autism spectrum disorders (ASD) (e.g., Ozonoff 1995; Hill 2004), response initiation has not been comprehensively studied in autism.

Verbal fluency tasks are a simple and common assessment method of the executive system. To perform such tasks, participants are asked to produce as many words as they can, according to a specific rule and during a short time interval. Such tasks have been widely applied in ASD, not only by using a global analysis of the overall production score (e.g., Geurts et al. 2004; Williams et al. 2006), but also by a qualitative analysis (e.g., Spek et al. 2009; Inokuchi and Kamio 2013).

Troyer, Moscovitch and Winocur (1997) consider that the overall score in verbal fluency tasks does not capture important qualitative aspects of the performance; furthermore, they described two important components of verbal fluency: the production of clusters of semantically or phonetically related words (clustering), and the ability to shift efficiently to a new subcategory (switching).

In what ASD is concern, few studies have evaluated the performance in verbal fluency tasks both in terms of global word productivity and the qualitative analysis, regarding the clustering and switching components (e.g., Spek et al. 2009; Inokuchi and Kamio 2013; Carmo et al. 2015). A discrepancy between the quantitative and qualitative analysis was reported, namely a global impoverished performance of the ASD group in verbal fluency, although no differences were observed in clustering or switching abilities. This pattern of performance led Spek et al. (2009), to argue, in agreement with Reverberi et al. (2006), that this pattern of poor global word productivity

Published online: 31 January 2017

combined together with normal clustering and switching could suggest an isolated initiation and activation deficit.

In verbal fluency tasks, the evaluation of word productivity as a function of time can add valuable information. It has been shown in healthy participants that over an initial period of time there was a relatively higher number of generated words, whereas a lower number of words was produced during the remaining time of the test (Crowe 1998 ; Fearneus and; Almkvist 1998).

Analyzing the performance quantitatively and qualitatively as a function of time, Carmo et al. (2015) directly evaluated the hypothesis put forward by Spek et al. (2009), i.e. that the discrepancy between poor performance in the verbal fluency task in ASD and the presence of preserved clustering and switching strategies could be due to an initiation deficit. Consistent with the predictions, in the first time period, high-functioning individuals with ASD produced significantly fewer words than the control group, yet in the last 30 s of the verbal fluency task, there were no differences between the two groups. This pattern of results led the authors to conclude that the abnormal performance and the aforementioned discrepancy of individuals with ASD in verbal fluency tasks could be determined by a deficit at the initiation of the task. This result is in line with the results of a study with the Hayling test, a sentence completion task and an alleged measure of response initiation (Shallice and Burgess 1996), in which a poor performance of a sample with ASD was reported in comparison to control participants (Booth and Happé 2010).

In the present study we aimed at providing further evidence for the differences—between individuals with ASD and typically developed control participants—observed in the initial time period of verbal fluency tasks being due to troubles in the response initiation. Besides the attempt to replicate (task 1) the findings of Carmo et al. (2015), we designed two other verbal fluency tasks in which we ultimately aim to attenuate and overcome the initiation of response impairment or to enhance it. In the former case (task 2), we tried to make the initiation of the task easier by providing an initial word cue. In the latter case (task 3) we reasoned that if the verbal fluency task difficulty increases, the initial difficulty in ASD would be bolstered.

Methods

Participants

Eighteen (1 female) high-functioning individuals diagnosed with ASD (HFA) and 24 typically developed (TD) individuals (3 females) participated in the study. Diagnose of ASD was assessed by two expert clinicians using the DSM-IV protocol (APA 1994). The Asperger's Syndrome Diagnostic Scale (ASDS) (Myles et al. 2001) was used to confirm the clinical evaluation diagnosis ($M = 105.28$, $SD = 9.83$) Additional, ASD inclusion criteria were: formal education above the 9th grade, older than 18 years, and a Wechsler adult intelligence scale (WAIS-III 1996) score above 70 points.

Both groups of participants were matched for age, for general cognitive abilities (IQ measured by Raven's progressive matrices), and for education. (see demographic Table 1 below).

Procedure

Participants were instructed that for each task they would have to produce as many words as possible according to a particular rule, within 1 min. Responses were digitally recorded and transcribed in order of utterance. The participants performed three semantic fluency tasks and the order of the tasks was kept the same throughout the tested groups. Subjects were instructed to produce words that belong to a given category or categories. The first task was a category fluency task without any initial word cue (i.e., a word that belongs to the category provided by the experimenter); the second task was a category fluency task with a cue provided by the experimenter ("Trousers" or "Fork"). The semantic categories used in these two tasks were *Kitchen Utensils* and *Clothing* and were counterbalanced across subjects. The third task was a two-categories switching task, where participants had to produce, in alternation, words from two different categories. The categories used were *Fruits* and *Body parts*. The order of these two categories was counterbalanced across the participants. We attempted to keep the words' production frequency from categories similar throughout the three tasks (Kitchen Utensils: 7.3; Clothing: 8.0; Fruits: 8.3; and Body parts: 8.4) (from Pinto 1992).

Results

For all three tasks, the number of correctly produced words was counted. Errors and repetitions were excluded. We compared the performance of both high-functioning

Table 1 Demographical information about the two groups

	Controls	ASD	*p* value
n	24	18	
Age (years)	28.17 (8.57)	29 (11.07)	0.8
RAVEN (raw score)	48.33 (6.43)	48.17 (8.48)	0.9
Education (years)	12.5 (2.37)	13.11 (2.25)	0.4

Mean and standard deviation are provided for each group individuals with ASD and Control groups by the average number of words produced in four time intervals. We counted the words produced by the participants in the following intervals: 0–15; 16–30; 31–45; 46–60 s. ANOVAs were performed on the average number of words, using the time interval (first, second, third, fourth) as within-subjects factors and Group (HFA, Controls) as a between-subjects factor.

Task 1: Verbal Fluency Without Providing Initial Word Cue

A main effect of Group was found significant (F (1,40) = 5.724, p = .022, $\eta_p 2$ = 0.12) with the HFA group producing overall less words (M = 3.72, SEM = 0.28) than the Control Group (M = 4.61, SEM = 0.244). A main effect of Time Interval was observed (F (3,120) = 139.725, p < .001, $\eta_p 2$ = 0.77) with a steady decreased of words produced along the task (0–15 s: M = 8.44, SEM = 0.33; 16–30 s: M = 3.63, SEM = 0.25; 31–45 s: M = 2.65, SEM = 0.31 and 46–60 s: M = 1.96, SEM = 0.24). The interaction effect Time Interval * Group (F (3,120) = 7.347, p < .001, $\eta_p 2$ = 0.15) was also observed (see Fig. 1). Subsequent independent samples t tests showed that the difference between the two groups was present in the first time interval (0–15 s: t(40) = 4.413, p < .001) but not in the remaining time bins (16–30 s: t(40) = 0.963; 31–45 s: t(40) = 0.467; 46–60 s: t(40) = −0.176, all ps > 0.341).

Task 2: Verbal Fluency, Providing Initial Word Cue

A main effect of Time interval was found (F(3,120) = 87.884, p < .001, $\eta_p 2$ =0.69) with a decrease in word production along the consecutive time bins (0-15s: M = 7.60, SEM = 0.35; 16-30s: M = 3.89, SEM = 0.28; 31–45 s: M = 2.38, SEM = 0.33; 46–60 s: M = 1.90, SEM = 0.25). No differences between groups were observed in this task (F(1,40) = 0.058, p > .8, $\eta_p 2$ = 0.001) (see Fig. 2). Although the interaction Time Interval * Group was found significant (F(3,120) = 3.030, p = .032, $\eta_p 2$ = 0.07), the subsequent t tests performed showed no differences between the HFA and Control groups in either time interval (0–15 s: t(40) = 1.875, p = .068; 16–30 s: t(40) = −0.8, p = .429; 31–45 s: t(40) = −0.530, p = .599; 46–60 s: t(40) = −1.741, p = .089).

Task 3: Verbal Fluency with Alternation Between Two Categories

It was observed a main effect of Group (F(1,40) = 7.939, p = .007, $\eta_p 2$ = 0.166), with the Control group producing, overall, a higher amount of words (M = 4.85, SEM = 0.20) than the HFA group (M = 3.98, SEM = 0.23) (Fig. 3). It should be noted, that the power of this effect is slightly higher than the one obtained in task 1. A main effect of Time interval was also observed here (F(3,120) = 72.408, p < .001, $\eta_p 2$ = 0.644) with a decrease in word production along the task (0–15 s: M = 7.38, SEM = 0.36; 16–30 s: M = 4.55, SEM = 0.27; 31–45 s: M = 3.07, SEM = 0.22; 46–60 s: M = 2.68, SEM = 0.18). The interaction effect Time Interval * Group was found significant as well (F(3,120) = 4.654, p = .004, $\eta_p 2$ = 0.104). As in task 1, subsequent t tests showed that differences between the groups were only observed in the first time interval (0–15 s: t(40) = 3.254, p = .002; 16–30 s: t(40) = 1.827, p = .075; 31–45s: t(40) = 0.818, p = .418 ; 46–60 s: t(40) = −0.523, p = .604).

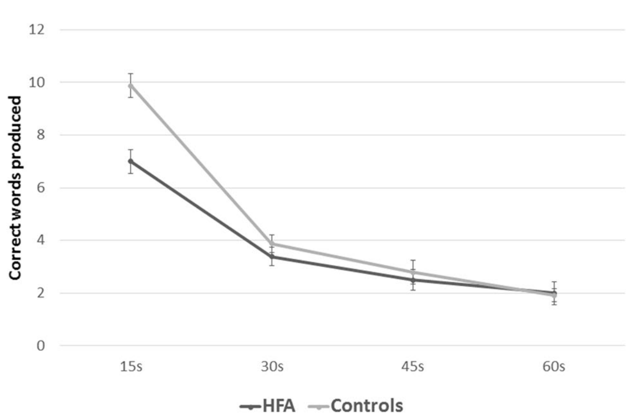

Fig. 1 Word productivity in the four time intervals (0–15; 16–30; 31–45 and 46–60 s) in the verbal fluency task without initial cue, for both the HFA and Control groups. *Error bars* are standard error of the mean

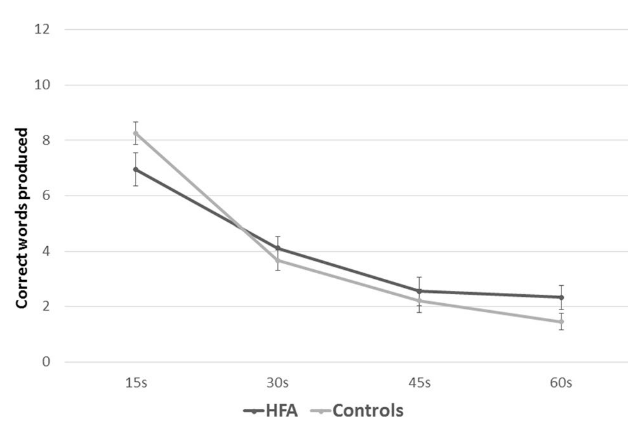

Fig. 2 Word productivity in the four time intervals (0–15; 16–30; 31–45 and 46–60 s) in the verbal fluency task with initial cue provided, for both the HFA and Control groups. *Error bars* are standard error of the mean

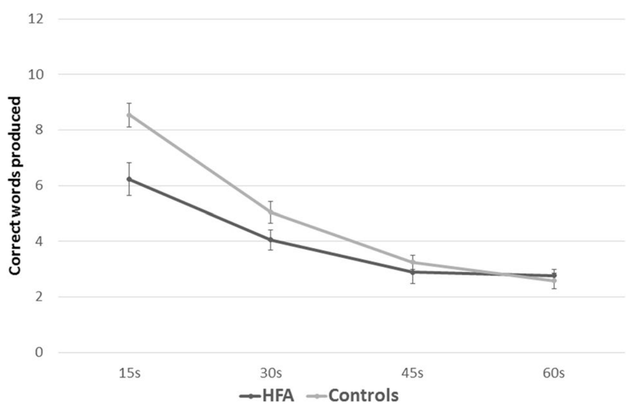

Fig. 3 Word productivity in the four time intervals (0–15; 16–30; 31–45 and 46–60 s) in the verbal fluency task with alternation between two categories, for both the HFA and Control groups. *Error bars* are standard error of the mean

Discussion

This study was designed in order to test and provide further evidences for the impairments observed in individuals with ASD, during the initial period of verbal fluency tasks (Carmo et al. 2015). We tested the hypothesis of these being related with an impairment of the initiation of response processes, by providing, for instances, an initial cue to try to circumvent them.

First of all, we have replicated in the verbal fluency task—without initial word cue (task 1)—the temporal effect and pattern of results reported in Carmo et al. (2015), i.e., a poor word production in individuals with ASD in the first 15 s of the task only. Furthermore, we observed the expected steady decrease in production of words in verbal fluency (Crowe 1998 ; Fearneus and; Almkvist 1998) in all three tasks, both for the ASD and control groups, with a greater amount of words being produced in the beginning followed by a decrease in word production for the rest of the time available.

In task 2 and 3 we aimed at manipulating the assumed initial processes impairment in ASD, by varying the difficulty of the task and its initiation. We predicted that providing an initial word cue (task 2) would aid the initiation of the task and thus decrease the differences between ASD and control groups. The fact that when an initial word was provided by the experimenter (task 2) the impairment in the ASD group vanishes, and differences between groups were no longer observed, is remarkable. In contrast, in task 3, we predicted that the alternation between two categories would make the task more difficult putting higher demands at its initiation and hence increasing the difference between the ASD and control groups. In accordance, we observed that the differences between the two groups were again present and slightly stronger than in task 1. Supporting the idea of an impairment in the initiation processes we did observe that our experimental manipulations in task 2 and 3 had an effect in decreasing and enhancing, respectively, the difference between ASD and control groups.

The possibility to aid and circumvent with a simple manipulation the problems at the initiation of this or other tasks, could lead to the development of good practices in the interaction with individuals with ASD in their daily living.

A component of the executive system that plays a role in cases of complex, non-routine or novel actions is the Supervisory Attentional System (Norman and Shallice 1986) and thus, a broader dysfunction of this component could be at the underpinnings of the initiation of response impairments in ASD. The hypothesis of a dysfunction of the Supervisory Attentional System in ASD has already been put forward by Hughes et al. (1994) based on a study in which these authors evaluated and observed deficits on the flexibility and the planning functions in this population. Therefore, we cannot rule out that the impairments of response initiation we observed are not specific, rather more general and related to this controlled component of the executive system.

In the present study we have provided further evidence showing that, in fact, individuals with ASD have deficits in the initiation of responses; furthermore, we have shown how a simple experimental manipulation can overcome and eliminate such limitations.

Acknowledgments The present work has been supported by a post-doctoral fellowships awarded to Joana C. Carmo (SFHR/BPD/79485/2011) by the Foundation for Science and Technology of Portugal and the POPH/FSE (European Union).

Author Contribution Conceived the study and design: JCC, ED and CNF; Neuropsychological assessment and recruitment: SP; Collected data: CS; Analyzed the data: JCC and ED; Draft the manuscript: JCC and CNF.

Compliance with Ethical Standards

Conflict of interest The authors declare that there are no conflict of interests.

Informed consent Ethical permission for the study involving human participants was granted by the Ethical committee of the Faculty of Psychology—University of Lisbon (Portugal), and each participant gave written informed consent.

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