Kamin-blocking in children

with Autism Spectrum Disorder

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Bachelor project in Cognitive Science Ba

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Abstract

The purpose of the present paper is assessing Kamin-blocking paradigm in children with ASD (Autism Spectrum Disorder). Kamin-blocking paradigm is a sufficient tool to discover the attentional mechanisms in associative learning, in which people with ASD are thought to have differences compared to neurotypicals by having difficulties in switching attention processes. Another phenomenon associated with ASD is a reduced generalization observed in perceptual learning tasks which could affect behavior in Kamin-blocking tasks as well. If difficulties in switching attention in ASD becomes apparent in the experiment, we should see an increased blocking effect, but if reduced generalization in ASD plays a role, we should obtain no blocking effect in the group of children participants with ASD compared to neurotypical children. So far, no studies have been made to assess Kamin-blocking in children with ASD. In the experimental procedure, a version of the disease diagnosis paradigm from Kruschke J. K. et al. (2005), fitted to our children participants, is implemented to discover the differences between the two groups of participants (ASD, NT) in Kamin-blocking. The results suggest no difference between the two groups and even no blocking effect at all in the data from the whole sample of participants. The design of the present experiment might have been insufficient to obtain a true blocking effect, but the lack of significant results of such a universal and widely accepted phenomenon as the blocking effect raise concerns related to the replication crisis in the field. The fact, there was no difference between the two groups of participants suggests that we might need to change our categorizing research tradition towards ASD. In this paper, I am going to discuss theories of cognitive processes in ASD (introduction) in relation to a Kamin-blocking experiment and elaborate on the questions and concerns these raise (discussion). I hope that this study, even if not publishable, by pointing out relevant and present conflicts between theories in the field could inspire future research.

Introduction

Autism Spectrum Disorder (ASD Kenny, L., Hattersley, C., Molins, B., Buckley, C., Povey, C., & Pellicano, E. (2016)) characterizes individuals whose processing of information and experience of the world is somewhat different than of neurotypicals. The phrase, Autism Spectrum Disorder, was made to acknowledge individual differences among people with the disorder by indicating being on a spectrum rather than being in a category or a box. The disorder ranges from low-functioning severe disability to high-functioning stable individuals until the spectrum shades into the non-clinical population (Baron-Cohen, S., Wheelwright, S., Skinner, R., Martin, J., & Clubley, E. (2001)). Even though the disorder is different in an individual to individual basis, they do have similarities among each other that are the basis of the diagnosis, also called autistic traits. These traits, depending on their severity in an individual on which the diagnosis based, are apparent in their everyday life and can even cause problems for them and their environment. These include inconvenience in social interaction, behavioral differences and they just seem to be interested in different things than people without ASD. For example, while neurotypical infants follow the eye-gaze of parents or other people, infants with ASD do not. Also, in kindergarten, they seem to have more interest in objects than in their fellow mates or nannies (Klin, A. (2011)). As their way of processing information is somewhat different, they usually have difficulties in learning and verbal acquisition. They tend to start speaking later than neurotypicals because they learn new words less frequently. They often form sounds differently as well, and there are severe cases of ASD in which individuals do not learn to speak at all in their entire life. Sometimes, a child with ASD can name his or her own body parts but fail to do the same on a picture, or the child can identify colors but fail to do a sorting task according to colors. In most cases, people with ASD have a repetitive behavioral pattern towards daily habits, for example, meal times at the exact time with the exact type, shape, number of the food. They are often unsuccessful in making social contact as they are perceived ’weird’ because of being unable to understand sarcasm, lie, manipulation or just follow the topic. What neurotypicals sometimes fail to recognize is that we need other perspectives as well, we do need different kinds of minds because they can be more rational in many situations and bring new ideas to the table only because their processing of information is indeed different (Grandin, T. (2010)). Moreover, if we can understand cognitive differences in ASD we understand neurotypical cognition better as well. The most important goal of all this is to change education continuously to fit everyone by informing policies about different kinds of minds (Grandin, T. (2010)). We are all different. Some of us can process information in an autistic way in one aspect and behave neurotypical in others (Baron-Cohen, S., Wheelwright, S., Skinner, R., Martin, J., & Clubley, E. (2001)). We should acknowledge that ASD can be in all of us just in different forms or processes and that is the beauty in us, humans, who can think, and every one of us differs in each of our own perspectives.

The non-social characteristics of ASD are becoming more and more important not just for diagnostic criteria but also for a better understanding of the processes lying behind them that are vital for behavioral interventions. These characteristics are differences in memory (see Bordignon, S., Endres, R. G., Trentini, C. M., & Bosa, C. A. (2015) for a systematic review), perception (see Mottron, L., Dawson, M., Soulières, I., Hubert, B., & Burack, J. (2006) for perceptual functioning in ASD), attention (see e.g. Plaisted, K., O'Riordan, M., & Baron-Cohen, S. (1998a)) on attention in ASD and on associative learning in ASD see (Preissler, M. A. (2008)). These cognitive characteristics are somewhat separate but mostly interrelated and co-dependent. If we consider one, we have to partly consider the other three as well, because one full process has several components (Basar, E. (2016)).

Research on associative learning became increasingly popular in the field with the primary focus on the classical conditioning of the eye-blink reflex (Reeb-Sutherland, B., & Fox, N. A. (2015)). In these tasks, the eye-blink reflex triggered with a brief air-puff to the cornea of one eye, an unconditioned stimulus. The caused blinking is then conditioned with a paired neutral stimulus (usually a tone) with the air-puff so that participants learn an association between the conditioned stimulus (tone) and blink which becomes the conditioned response to the tone. Two main variations exist of the classical conditioning of the eye-blink reflex paradigm. One is delay conditioning where the unconditioned stimulus (the air-puff) occurs while the conditioned stimulus (tone) is presented as well just after some delay so that the onset of tone predicts the air-puff and then they are presented together. In trace conditioning, there is a short interstimulus interval between the conditioned stimulus (tone) and unconditioned stimulus (air-puff), so that the tone predicts the air-puff, but they are presented separately. In the delay conditioning scenario, participants have to learn the association between tone and blink which is identical in trace conditioning, although, in delay conditioning, they also have to learn correctly time their blinks so that at the onset of the air-puff one's eyes are entirely closed to protect them from the air-puff. In trace conditioning, this is not apparent because of the interstimulus interval (the period between the offset of the tone and the onset of the air-puff) which signals the air-puff coming. So, there are two processes we can discuss in delay conditioning of the eye-blink reflex, one is associative learning, and the other is temporal timing whereas in trace conditioning only requires the acquisition of the association between the conditioned stimulus and response. The main finding, in the context of ASD, was that participants with ASD had altered timing in delay classical conditioning of the eye-blink reflex but were capable of acquiring associations between tone and air puff as in trace conditioning their performance was just like that of the control group (Oristaglio, J., Hymen West, S., Ghaffari, M., Lech, M. S., Verma, B. R., Harvey, J. A., Welsh, J. P., & Malone, R. P. (2013)). The difference in delay conditioning in ASD is even more interesting when considering neural mechanisms. The two processes, association learning, and temporal timing has been linked to different neural circuits; association encoding to the fronto-hippocampal network, and temporal timing to cerebellar, brain stem network (Christian, K. M., & Thompson, R. F. (2003)). These suggest that people with ASD have impairments in cerebellar motor processes responsible for temporal timing, while their fronto-hippocampal network remains intact, meaning that also their association encoding mechanisms should be intact as well. On the contrary, a recent systematic review reported a wide range of associative memory impairments among individuals with ASD (Bordignon, S., Endres, R. G., Trentini, C. M., & Bosa, C. A. (2015)). If encoding associations should work perfectly in people with ASD, how come they have associative memory impairments?

As mentioned before, we cannot separate learning from memory, perception or attention (Basar, E. (2016)). All four influence each other and work co-dependently. To properly process information, one needs to focus attention, learn the association, then store that in memory and also the correct perception of the information is as well essential and apparent in the process. A key function that can strengthen associations, and which has been showed to be different in ASD, is attention. Three main differences in attention mechanisms have been reported: increased sensory capacity in selective attention tasks (Remington, A., Swettenham, J., Campbell, R., & Coleman, M. (2009)), enhanced visual search and discrimination by reduced generalisation (Plaisted, K., O'Riordan, M., & Baron-Cohen, S. (1998a & b)), and difficulties experienced in tasks which require one to switch attention frequently (Reed, P, & McCarthy, J. (2011).).

Recently, a new theory of ASD has been formulated to explain the differences in the above mentioned cognitive aspects. It is called the volatility theory (Lawson, R. P., Mathys, C., & Rees, G. (2017)). According to the authors, people with ASD experience the world much more volatile than neurotypicals. One of the main markers for ASD diagnosis is the repetitive behavioral patterns characterized by an insistence on sameness and avoidance of changing, unpredictable stimuli. Obsessive attentional fixation of stimuli which is favorable, because of being highly predictable, can result in the exclusion of other less predictable, changing or loud stimuli which could bear the same or even higher importance factor than their preferred stimuli. Thus, attention switching difficulties could be explained by volatility theory considering, when out of two types of stimuli, to which one should pay even attention, one type is more predictable, and the other is less. It would cause a hard time for an individual with ASD to switch attention from the more predictable to the less, resulting in an increased attentional focus on one type and decreased or even none on the other type of stimuli.

Another difference in attention among people with ASD, which can be explained by volatility theory, is the enhanced visual search and discrimination by reduced generalization. The explanation to these comes from another component of the theory which is the decreased surprise among people with ASD. According to the authors (Lawson, R. P., Mathys, C., & Rees, G. (2017)), overlearning volatility results in not updating prior knowledge thus making one unable to make predictions of future events or stimuli and reduce surprise of unexpected events or stimulus. They showed that decreased surprise even has predictive power for ASD traits severity. In their experiment, they presented tones of 3 frequencies followed by a house of a face. The setup consisted of more stable, high probability periods and more volatile, low probability periods relating to the predictive power of the three kinds of tones on the visual stimuli (house or face). They recorded beliefs of participants as choice data (house or face), reaction times, and neurophysiological data. In their experiments, adults with ASD showed reduced behavioral and neurophysiological responses to unexpected stimuli than neurotypicals. They also noticed increased responses in ASD to expected stimuli than neurotypicals, suggesting that their level of surprise remained the same for both types of stimuli. These phenomena indicate that they fail to update their knowledge during the task, thus, having decreased distinction between repeated or familiar and novel stimuli, so their generalization ability reduced. Enhanced perceptual discrimination abilities of people with ASD and the possible explanation for it, their reduced generalization, have been proposed by Plaisted, K., O'Riordan, M., & Baron-Cohen, S. (1998a). This study revealed that participants with ASD have an enhanced discrimination skill in complicated perceptual learning tasks which is built-in, meaning that it does not change with training on the task because of a reduced generalization of stimuli. *The overarching purpose of the present paper is to investigate these two differences of attention - difficulties in switching attention from more predictable stimuli and reduced generalization - in associative learning among people with ASD.*

One of the main paradigms for investigating the influence of attention in associative learning is the Kamin-blocking paradigm (Kamin, L.J. (1968)). In this paradigm, there are two types of stimuli that constitute the so-called blocking effect. One is the blocking stimulus (A), and the other one is the blocked stimulus (B). In a Kamin-blocking task in the first training phase, the blocking stimulus A is conditioned to associate it with a specific response R until this association is learned. Then, in the second training phase, the blocking stimulus A is paired with the blocked stimulus B and are conditioned to associate them with the same response R as in the first phase with another pair of stimuli C-D (control stimuli) associated with another response Q until both associations are learned.

Then, in the third, testing, phase, stimuli pairs are taken apart and mixed with each other forming pairs of A-C and B-D. According to the paradigm in cases with a pair like A-C which involves the blocking stimulus, participants would respond according to the blocking stimulus A (response R). Whereas in a pair like B-D which involves the blocked stimulus, participants would respond according to the other or control stimulus which is in this case D (response Q). The described phenomenon is the blocking effect because the learning of the blocking stimulus A blocks the learning of the blocked stimulus B as A was conditioned for a longer time and was learned by only itself, whereas B was conditioned for a shorter time and was learned with A and never alone. According to Kruschke, J. K. et al. (2005) blocking occurs because of a failure to shift attention from the highly predictive stimulus A to the newer redundant stimulus B. *If this is the case, then we should expect people with ASD to be associated with an increased Kamin blocking effect as they have difficulties in switching attention from a highly predictive stimuli (A) to a less predictive one (B).*

However, it would also be logical to propose the opposite and associate ASD with smaller blocking effect because of a reduced generalization in learning tasks. If people with ASD do not update their knowledge and they experience expected as unexpected, they might fail to recognize familiar stimuli. In this scenario, they would handle blocking stimulus A as novel at the same level as they would handle all other stimuli (B, C, D). It would not mean that they would not learn the associations - they would learn them as well as any other neurotypical participant -, but while for a neurotypical person the associations for blocking stimulus A would be strengthened with the experimental setup and would block stimulus B, for a person with ASD this might not be the case. *They might learn all the associations evenly and then in the testing phase half of the time they would choose according to one of the stimuli in the pair (A or B) and half of the time according to the other one (C or D) which would show no blocking effect at all.*

In the present experiment, we use a modification of the disease diagnosis paradigm based on Kamin-blocking from Kruschke, J. K., Kappenman, E. S. & Hetrick, W. P. (2005) in a way that it fits our children participants. The hypothesis comes from the previous reasoning: *If the volatility theory is correct and Kamin-blocking is indeed* *apparent in children, then we should expect a blocking effect for the control group and either an increased blocking effect - because of difficulties in switching attention -, or no or reduced blocking effect - because of reduced generalization -, for the group with ASD. It is also highly possible that we will not have a general conclusion of which of the two scenarios happened because of individual differences among participants with ASD.* One might obsessively fixate on the blocking stimulus because of its highly predictive power and fail to switch attention to the blocked or any other stimuli. However, it is evenly possible that one might just handle each stimulus at the same level as all the stimuli in the training phases are predictive and ’trustworthy’ considering that all are associated with one response. It is just in the testing phase where they are mixed and can point to both response types. *In the following experiment, we further investigate these questions with a follow-up discussion.*

Research Methods

Ethics and Participants

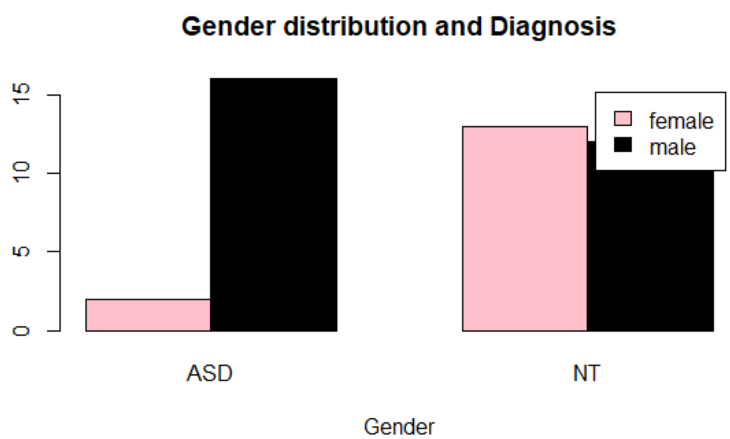
Before data collection, there was a request sent to the Research Ethics Committee of Region Midtjylland in November 2014 which informed the Committee about the purpose and procedure of the present study. The actual data collection was carried out in the spring of 2015 in Aarhus. The study involved no intervention, no use of invasive methods or collection of biological material. Furthermore, it was entirely anonymised; there has been no personal ID or any identification sensitive information collected. Parents received full information about the study (both written and oral) including purpose – assessing differences in learning mechanisms -, procedure – of the actual experiment and follow-up diagnostic tests -, requirements for participation – between the age of 8-15 years with or without ASD diagnosis -, duration of the experiment – both the actual experiment and cognitive assessment -, and location of the experiment – children' own school. Parents had to give informed consent for children to participate including information about when researchers can visit the school of the child and carry out the experiment, also agreed with the child's teacher in question. They had to submit this consent form before the experiment by email or mail. Both the parents and children were informed that participation is entirely voluntary, they can withdraw their consent at any time during the experiment without any explanation. Children have also been informed about the procedure of the experiment as well before the first trial verbally. Participation was compensated with a 100 DKK gift card that can be used in several stores (www.supergavekortet.dk).

Our participants consisted of children diagnosed with ASD but attend regular school and also those who receive special education, and neurotypicals diagnosed with no mental condition of any kind, being the control group of the study, with the additional requirement of having no family members (siblings or parents) diagnosed with ASD. All participants had to be in the age range of 8-15. The study involved two sessions. One with the actual experiment (about 40 minutes) and another one assessing cognitive traits with the WISC-IV ((1949). Review of Wechsler Intelligence Scale for Children. Journal Of

Consulting Psychology, 13(6), 453-454) test (about 40-60 minutes) with the components of Full Scale Intelligence Quotient (FSIQ), Verbal Comprehension Index (VCI), Working Memory Index (WMI), Perceptual Reasoning Index (PRI) and Processing Speed Index (PSI). WISC-IV served as a tool to match the participants from the two groups (with ASD and NT). Deviations of more than two standard deviations from the typical area of the WISC-IV IQ test resulted in exclusion from the experiment as it would have affected the results. Furthermore, an Autism Diagnostic Interview-Revised (ADI-R) were conducted with the parents of children with ASD to validate the diagnosis.

Data were collected from 21 children with ASD and 25 children without (neurotypicals – NT). There were three exclusions among participants with ASD because of not meeting age, IQ requirements or due to withdrawal from the experiment. Two excluded participants who completed the experiment received the compensatory gift card as well. (Unfortunately, I could not get further information about exclusions.) Eventually, data came from 18 participants with ASD of which there were 16 males (88.9%). Out of 25 NT participants, there were 12 males (48%). While the distribution of gender among NT participants is nicely representative of the population and balanced, the one among participants with ASD is unbalanced. In the population, there are in fact four times more males with ASD than females, but in our sample, this ratio is eight times more for males (Plot 1). The mean age of the NT group was 10.50 with the standard deviation (SD) of 1.91, for the ASD group the mean was 12.44 with the SD of 1.82. The difference between the two groups regarding age was significant (p-value of 0.006). In the data from the NT-s there were 11 missing data for age but none from the ASD group. Mean of the FSIQ for the NT group was 106.72 with an SD of 8.50 and for the ASD group, it was 100.57 with an SD of 10.18. Difference between the two groups for FSIQ was not significant (p-value of 0.115). For PRI and PSI, the means were 35.84 with 4.87 SD and 19.72 with 2.91 SD for NT, 36.43 with 6.8 and 18.29 with 6.05 for ASD, respectively with no significant difference between the two groups indicated by the p-values of 0.797 and 0.379, respectively. Mean of VCI for the NT group was 32.68 with an SD of 5.57, the same for the ASD group was 29.85 with 5.27 with no significant difference between the two groups ($p = 0.241$). Lastly, the mean of WMI for NT and ASD groups were 16.43 with 3.82 SD and 20.88 with 2.55 SD with a significant difference between the two groups ($p=0.001$).

For all the data of the WISC-IV test, there are 11 missing data from the same participants for each of the measured components, in the ASD group. Scores of the ADI-R were recorded just for the group of participants with ASD as only their parents had to participate in an interview. The mean for ADI-R was 39.31 with an SD of 13.08. It would have been sufficient to try to match the two groups, especially in age, IQ, and verbal age, with the sufficient 'matchit' package in Rstudio but I had a lot of missing data and a small sample size unfortunately which inhibited the attempt. (see Table 1 for a summary of the scores)



a Plot 1 Gender distribution in the two groups of participants (with ASD and NT)

	ASD	**NT**	**p**
N	18	25	
Gender = male (%)	16 (88.9)	12 (48)	0.014
Age (mean (sd))	12.44 (1.82)	10.50 (1.91)	0.006
FSIQ (mean (sd))	100.57 (10.18)	106.72 (8.50)	0.115
PRI (mean (sd))	36.43 (6.8)	35.84 (4.87)	0.797
PSI (mean (sd))	18.29 (6.05)	19.72 (2.91)	0.379
VCI (mean (sd))	29.86 (5.27)	32.68 (5.57)	0.241
WMI (mean (sd))	16.43 (3.82)	20.88 (2.55)	0.001
ADI-R (mean (sd))	39.31 (13.08)	NA	NA

b Table 1: participant assessment: this table shows means, standard deviations (sd) and p-values (p) of different properties of the participant data in the two groups of participants; rows indicate the different components of participant information including number of participants, gender, age and the different components of the WISC-IV test and ADI-R, columns indicate the two participant groups (with ASD and NT), and there is a separate column for p-values indicating the significance of the differences between the two groups for each measure.

Procedure

Participants sat in front of a PC, and the experiment was carried out using Psycopy 1.84.2. In line with the Kamin-blocking paradigm, the experiment consisted of 3 phases. Two training phases – one early and one late -, and a testing phase. In the training phases, participants had to learn which animal likes to play with which specific toy. In the testing phase, the blocking effect was measured. There were four animals displayed on the screen, a lion, a giraffe, a zebra and an elephant, as response options. Responses were recorded by pressing one of the four arrow keys on the keyboard. At each trial, a specific colored and shaped toy appeared in the middle of the screen and participants had to decide which animal likes that specific toy by pressing one of the arrow keys. Children were instructed to pay attention to the color and shape of the stimuli and choose according to these properties. In each phase, four stimuli were randomly sequenced appearing at least four times each. One phase consisted of at least 16 trials. In the first two training phases, the session continued until there was only one mistake per 16 trials to ensure learning of the specific stimuli. After indicating their response at each trial they got a feedback if it was correct or not, a tick or a cross in the middle of the screen, but just in the training phases. Participants were instructed, before the first two training phases, that they will get feedback. There were no time limits; the program was designed to wait for a response and then show the next stimuli. In the testing phase, there were fix 16 trials with each stimulus presented four times. In this phase, there were no feedbacks as there were no correct answers because of the nature of the stimuli at this stage, in line with the paradigm. On the other hand, they did get notified about that their responses were recorded.

In Table 2 all stimuli are explained for each phase. Each stimulus had two dimensions, one color, and one shape, out of which one consisted the blocking or the blocked stimulus. The blocking or blocked stimuli as one dimension of the ’toy’ were crossed over to ensure that participants do not favor one type of feature over the other. In Table 2 properties marked with a yellow color code are the blocking stimuli, those marked with blue are the blocked ones, and the two green fields indicate the paired composition of them. Both blocking and blocked stimuli consisted of one color and one shape, separately presented but paired with a distractor dimension, except the second training phase where blocking and blocked stimuli were paired. There were two stimuli of each kind. In the early training phase, only the blocking stimuli (A1, A2) was learned with two other distractor stimuli (F1, F2). Then in the late training phase, blocking stimuli were paired with blocked stimuli (A1-B1, A2-B2) and their pairings were learned with two control stimuli (C1-D1, C2-D2). In the testing phase, blocking and blocked stimuli were presented separately paired with the control stimuli (A1-C1, A2-C2, B1-D1, B2-D2). In the testing phase, participants could choose either according to target (blocking or blocked stimuli) or according to control stimuli. If the paradigm worked, and a blocking effect could be measured, in cases where blocking stimuli was present participants would choose according to target (blocking stimuli) whereas in cases where blocked stimuli were present they would choose according to control stimuli. For all the phases choice data and reaction times were recorded.

Early training phase	**Color**	**Shape**
A1	blue	triangle
A2	red	square
F1	green	pentagon
F2	yellow	hexagon
Late training phase		
A1 – B1	blue	circle
A2 – B2	orange	square
C1 – D1	brown	rectangle
C2 – D2	purple	rhombus
Testing phase		
B1 – D1	brown	circle
B2 – D2	orange	rhombus
A1 – C1	blue	rectangle
A2 – C2	purple	square

C Table 2: stimuli description: different specific properties of stimuli were assigned as blocking or blocked stimuli; those marked with yellow are the blocking stimuli, those with blue are the blocked stimuli and the two fields with green indicate the pairings of blocking and blocked stimuli. Capital letters indicate the type of the stimuli: A – blocking, B – blocked, C&D – control stimuli, F – distractor stimuli, and numbers are there just to show that we had two stimuli for each kind.

Analysis and Results

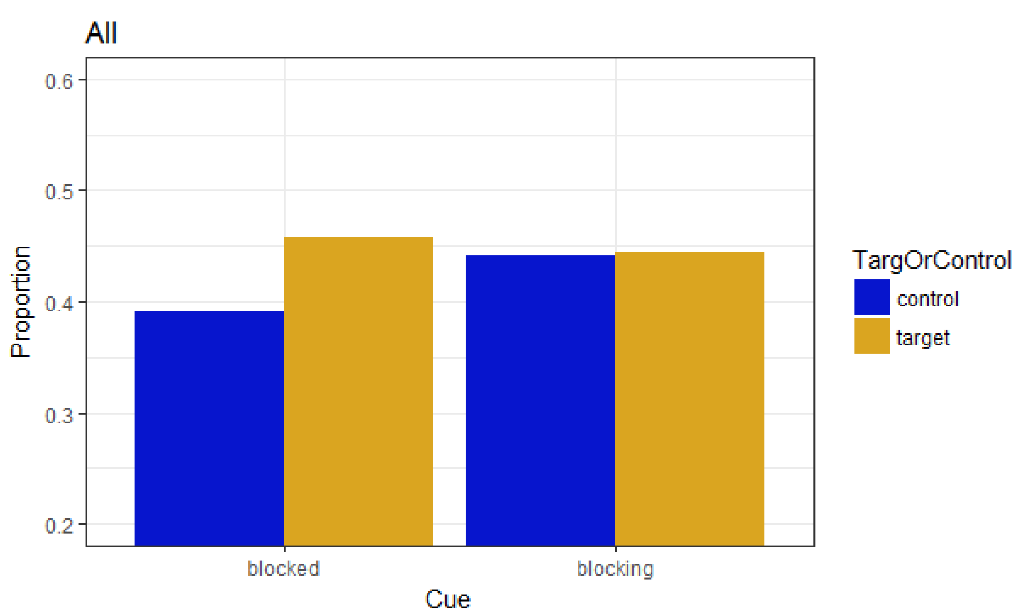
The analysis was carried out using Rstudio 3.4.2 (28.09.2017). Only choice data from the testing phase needed to be analyzed. In the preprocessing of the data subject ID and diagnosis were subtracted from the file name. Other essential information, such as the type of stimuli (blocking or blocked involved), choice according to target or control, and proportions of responses were subtracted from the files using a loop to get all participants' data. Table 3 shows an example of the dataset.

For making the analysis easier, a new column was added according to 'Cue' and 'Control'. The new column consisted of 4 response types; correctA when responses were made according to the target stimuli (blocking stimulus itself) when blocking stimuli were present, correctB when responses were made according to control stimuli when blocked stimuli were present, and errorA when responses were made according to control stimuli when blocking stimuli were present, errorB when responses were made according to target stimuli (blocked stimulus itself) when blocked stimuli were present. To test if the paradigm worked at all, in both groups a one-way or repeated measures ANOVA was conducted with a fixed within-subjects factor of the new column (called effect) and a random factor according to subject ID to account for measuring one response type just once per subject. For assessing group differences, a two-way 2 (group: ASD or NT) x 4 (effect: correctA, correctB, errorA, errorB) mixed-design ANOVA was used with a within-subjects factor of effect, a between-subjects factor of group (ASD or NT), their interaction – as we would like to see if group had an impact on the effect -, and a random factor of subject ID. For illustration three bar plots are shown in Plot 2 and 3, one for the overall blocking effect, one for the blocking effect in group ASD and one for group NT.

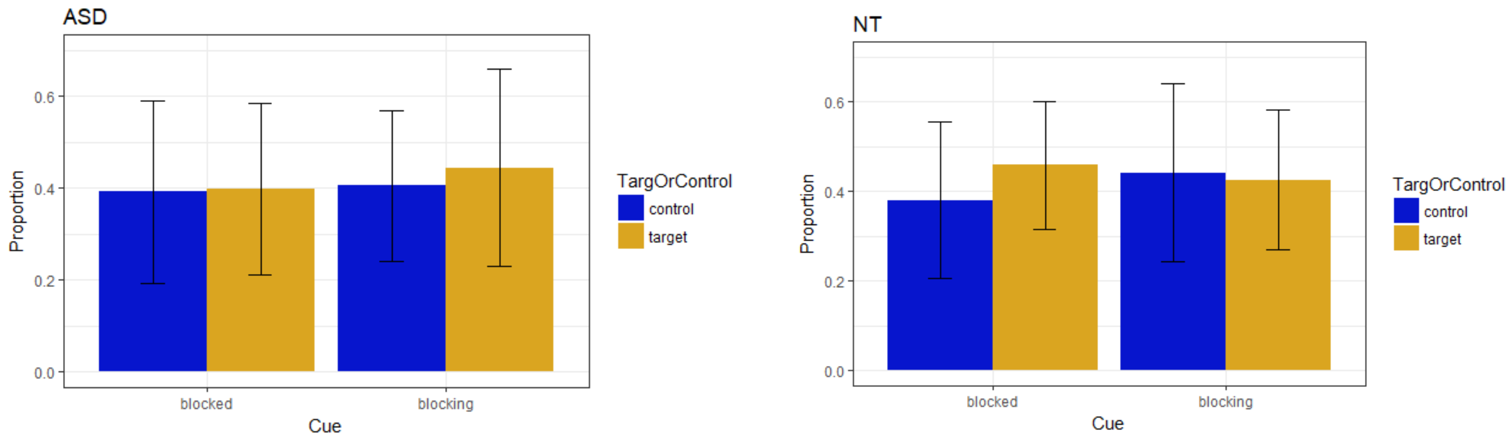
A one-way or repeated measures ANOVA was conducted to test for an overall blocking effect of the participants in the testing phase of the experiment. No significant main effect was found for the effect factor in the data, $F(3) = 0.74$, $p = 0.53$. This means that participants were responding according to chance level ($p=.5$) like a machine would do which denies the existence of a blocking effect, excepting that the null hypothesis is true. A two-way 2x4 mixed-design ANOVA was carried out to assess group differences according to diagnosis (ASD or NT) in the blocking effect (effect) for the testing phase of the experiment. No significant effect was found for group, $F(1) = 0.357$, $p = 0.551$, for effect, $F(3) = 0.730$, $p = 0.535$, or for the interaction of the two, $F(3) = 0.476$, $p = 0.699$. This indicates that adding group did not make any difference, in none of the groups were any significant blocking effect apparent, and the two groups were not significantly different from each other in their separate blocking effect scores. Means and standard deviations are reported in Table 4.

Sub	*Cue*	*Control*	*Proportions*	*Group*	*Effect*
1	*blocked*	*target*	*0.333333*	*ASD*	*errorB*
1	*blocked*	*control*	*0.543332*	*ASD*	*correctB*
1	*blocking*	*target*	*0.432222*	*ASD*	*correctA*
1	*blocking*	*control*	*0.416666*	*ASD*	*errorA*
2	*blocked*	*target*	*0.214566*	*NT*	*errorB*
2	*blocked*	*control*	*0.543278*	*NT*	*correctB*
2	*blocking*	*target*	*0.637890*	*NT*	*correctA*
2	*blocking*	*control*	*0.121134*	*NT*	*errorA*

d Table 3: example data: column; subject ID, type of the stimulus whether blocking or blocked cue were present if the responses were made according to the target (cue itself) or the control stimuli, proportions of each type of response, and subject group according to diagnosis



e Plot 2: bar plot of the overall blocking effect in the data: on the y-axis, the proportion of responses are shown, on the x-axis the two cues (blocking and blocked) are presented, the colors indicate effect as if the responses were made according to target (for blocking that is correctA, for blocked it is errorB) or the control *(for blocking that is errorA, for blocked it is correctB). No significant main effect was found for the effect factor in the data, F(3) = 0.74, p = 0.53.*



f Plot 3: bar plots of the blocking effect in the two groups (ASD on the left, NT on the right): on the y-axis, the proportion of responses are shown, on the x-axis the two cues (blocking and blocked) are presented, the colors indicate effect as if the responses were made according to the target (for blocking that is correctA, for blocked it is errorB) or the control (for blocking that is errorA, for blocked it is correctB). No significant effect was found for group, F(1) = 0.357, p = 0.551, for effect, F(3) = 0.730, p = 0.535, or for the interaction of the two, F(3) = 0.476, p = 0.699.

Effect	*Overall*	*NT*	*ASD*
correctA (mean(sd))	*0.43 (0.18)*	*0.43 (0.16)*	*0.45 (0.22)*
correctB (means(sd))	*0.39 (0.18)*	*0.38 (0.17)*	*0.39 (0.20)*
errorA (mean(sd))	*0.43 (0.18)*	*0.44 (0.20)*	*0.41 (0.16)*
errorB (mean(sd))	*0.43 (0.16)*	*0.46 (0.14)*	*0.40 (0.19)*

g Table 4: report of the means and standard deviation of blocking effect for the overall data, for the NT group and for the ASD group, rows represent the 4 possible responses (correctA when at blocking cue the target was chosen, correctB when at blocked cue the control was chosen, errorA when at blocking cue the control was chosen, and errorB when at blocked cue the target was chosen)

Discussion

The purpose of the current study was to assess Kamin-blocking paradigm in ASD by accepting that the paradigm exists as it is widely accepted and should have been a reliable and robust effect according to the literature in the field. On the other hand, no blocking effect was observed in the present experiment on the Kamin-blocking paradigm ($F(3) = 0.74$, $p = 0.53$) in either of the two participant groups (ASD, NT). So, the null hypothesis was accepted, that no blocking effect played a role in this associative learning task designed to show blocking effect. *The question arises, what could have happened as blocking effect thought to be a universal and reliable behavioral phenomenon?*

First of all, our small sample size did not reach a limit of power to detect a significant result which could have played a role. On the other hand, a recent study (Maes, E., Boddez, Y., Alfei, J. M., Krypotos, A.-M., D'Hooge, R., De Houwer, J., & Beckers, T. (2016)) reported 15 failed replications of the original Kamin-blocking effect observed in experiments with rodents indicating that maybe the present failure of obtaining a true blocking effect is not unique, and there are indeed some objections to it. Maes E. et al. (2016) do not deny the existence of blocking effect; they just state that „*The results presented here do suggest that a true blocking effect is more difficult to obtain than one might assume from the literature and that we lack insight into its boundary conditions.*" (Maes, E., Boddez, Y., Alfei, J. M., Krypotos, A.-M., D'Hooge, R., De Houwer, J., & Beckers, T. (2016) p.37) The article elaborates on a replication crisis as well, relating to other widely accepted but recently failed-to-be-replicated phenomena in behavioral psychology like social priming. It takes the example of social priming and points to the research development – finding the conditions and boundaries under which social priming can be observed - after failing to replicate the phenomena resulting in a controversy literature. In the discussion, the authors suggest this would be an ideal avenue for the blocking effect as well. The study addresses issues like publication bias. There were probably more failed attempts to replicate blocking effect, but the problem is that those studies are unpublished because of interest in the field. Some researchers would even just continue conducting experiments until blocking effect is observed, and then they would only publish that one, also because of the widely accepted universal nature of the phenomenon. *The authors argue that blocking effect is over promoted and future research should focus on determining the conditions under which a true blocking effect can be observed and also under which it cannot.* The paper also makes readers aware of the misuse of blocking. In one of his first papers on blocking (Kamin, L. J. (1969)) Kamin defines surprise as a driving and essential factor for learning as it strengthens the association between R (response) to A (blocking stimulus) in the initial training phase. In his experiment conducted on rats, his surprising blocking stimulus is a foot-shock, and his blocked stimulus is a bright light. *Surprise could be an important factor under which blocking effect can be observed.* Even though Maes E. et al. 2016 included this factor of surprise and still reported 15 failed replications, it still worths to consider adding surprise factor to our experiment, of course not in such an aversive approach like a foot-shock. To give an example, maybe some bright light or surprising tone for trials could be added to the first training phase including the blocking stimuli A1 and A2.

The design of our experiment could have also played a role in not observing a true blocking effect at all. Initially, this experiment was designed on the basis of the disease diagnosis paradigm from Kruschke, J. K., Kappenman, E. S. & Hetrick, W. P. (2005) but with some changes to fit our children participants. Before this study, another unpublished research was done by Skewes J.C. et al. where true blocking effects were observed in adult participants both with ASD and neurotypicals. The experiments in this study were identical to the original disease diagnosis paradigm. The question is what are the differences between these designs and if differences could be responsible for the lack of results in the present research. The first and most obvious difference is that, here, we used objects with two dimensions of shape and color to fit our children participants, whereas, in the disease diagnosis paradigm, words were used. It is unlikely that this made the difference because the visual nature of the stimuli did not change or made a difference in the blocking mechanism. In our experiment, the two dimensions of the objects constituted the blocking and the blocked stimuli and were crossed over to cancel out the possibility that participants would favor one dimension (e.g., color) over the other (e.g., shape) and vice versa. However, the two dimensions indicated one object that was hard to separate. Probably participants processed the dimensions together as a whole making blocking and blocked stimuli hard to distinguish in the process resulting in no blocking effect. Also, in the original disease diagnosis paradigm in the first training phase, blocking stimuli and distractor stimuli are conditioned only by themselves, paired with nothing. Whereas, in our experiment, already in the initial training phase both were paired with additional distractors, which is more likely to play a role in the lack of significant results. If I or anyone will do the same or similar experiment again, I would suggest having more objects as the stimuli for each trial to form more explicit blocking and blocked cues and making the design be able to train blocking stimuli alone. For example, in the first training phase 6 objects could be used at each trial having either same color but different in shape or same shape but different in color, then, in the two other phases again 6 objects would be used at each trial but being the same both in shape and color according to the pairing rules of the paradigm. To cancel out that the age of our participants (children whereas in Skewes J.C. unpublished paper they were adults) made any differences, in future research, one should add an adult control group as well for the same experiment.

According to two studies which were made to assess components on associative learning (Rescorla, R. A., & Wagner, A. R. (1972) and Mackintosh, N. J. (1975)) argue that it is not only the nature of the stimuli which has an effect on the learning process but reinforcement is an essential driving factor in associative learning as well. Both state, that *reinforcement is vital for learning tasks and strengthens the associative strength between stimuli and response.* In our experiment, we had a kind of reinforcement in the training (learning) phases indicated by a tick or a cross if the response was correct or incorrect but that was maybe not enough. In the original paper on the disease diagnosis paradigm (Kruschke, J. K., Kappenman, E. S. & Hetrick, W. P. (2005)), the experiments included feedbacks as well similar to ours, but theirs were a bit more explicit with “Yes! The correct answer is [word].” and “Wrong! The correct answer is [word].” (p.836), and having a brief buzzing sound accompanying incorrect feedback as a kind of negative reinforcement which was something that participants probably wanted to avoid as well. Stating more explicitly, they probably wanted to avoid answering incorrectly, but maybe the buzzing tone added a further uncomfortable sensation to incorrect responses resulting in an even more elevated behavior towards answering correctly and learning associations more effectively. *From the previous reasoning, it comes that it would have been beneficial to* *include some additional, more explicit reinforcement in the feedbacks throughout the two training phases of our experiment.* It also has to be considered that participants were children, so maybe getting money or points would not be so efficient as a type of reinforcement. I would instead add emotional reinforcement by showing them happy or sad animal faces to which children could more relate to, and may be accompanied by some sounds as well similar to the original experiments of Kruschke, J. K., Kappenman, E. S. & Hetrick, W. P. (2005), so there would be another sensation that children would seek or try to avoid.

The other main finding of the present study was that no significant difference was observed between the two participant groups (ASD and NT $F(1) = 0.357, p = 0.551$). However, if we take another look at the plot of the blocking effect in the group with ASD (Plot 3 left panel), we can see a slight blocking effect for the blocking cues. This indicates that there were indeed some participants fixating on the blocking stimuli, just not enough to show a significant difference or even a true blocking effect. *This slight difference supports the initial idea that processing in ASD is different in an individual to individual basis.* Some participants from the group with ASD fixated on the blocking stimuli showing difficulties in switching attention, whereas some just considered it as novel supporting reduced generalization hypothesis. *To solve the conflict between these two main hypotheses, a more complex experimental setup should be made in future research on ASD including tasks of different paradigms assessing either of the two mechanisms (switching attention, generalization)*. This more complex setup should then involve discrimination tasks for assessing reduced generalization phenomenon and a better fitting, more explicit version of the current blocking task (examples mentioned above for changing the design) to assess switching attention mechanisms. After the experiment, the results from the two tasks should be compared for each individual at first for more valid assessment, and then groups should be identified by the analysis of individuals. Groups could be like; participants with ASD having reduced generalization and switching attention difficulties, having reduced generalization, or switching attention difficulties only, but of course it depends on the actual data one would obtain. A meta-analysis would be insufficient here as it would lack considering individual differences (not the same population of participants) and publication bias.

When assessing learning differences, it is sufficient to consider evidence accumulation processes. When making a decision between two choices, one, as an agent, needs a certain amount of evidence to decide on one response option over the other. *To assess evidence accumulation mechanisms, reaction times should be analyzed with the appropriate drift-diffusion model* (Luzardo, A., Alonso, E., & Mondragón, E. (2017)). I had the attempt to do so, but after preliminary analysis with t-tests on the reaction times of the testing phase showed no significant differences, giving no further details about the process, I decided to skip it from the main analysis and results part of my paper as it would just be an unnecessary fuss. On the other hand, it is sufficient to mention it here as the model as a tool could give more opportunities to assess individual and group differences in the above-mentioned complex experimental setup. Preliminary, drif-diffusion models are Bayesian hierarchical models being fit on each participant's data with prior distributions which would allow one to add priors according to groups (previous paragraph) obtained from a previous discrimination task. For example, priors for bias in the model. If a participant has a high indicator for reduced generalization, that would mean an unbiased model for blocking task as we assume that this participant would choose between the two response options perfectly randomly (0.5), for instance. It would also worth to try to correlate AQ (Autism Quotient) scores for repetitive behavior both with reduced generalization indicator – if one has low AQ score for repetitive behavior would mean an even more reduced generalization -, and with blocking effect – if higher score indicates higher blocking. *In general, it might be more correct to collect AQ scores from all participant regardless of diagnosis, and rather conducting correlation analyses than comparison analyses between groups of participants diagnosed with ASD and participants diagnosed with nothing.* From the definition of ASD and autistic traits and the fact that everyone could have some autistic traits, this seems a more sufficient approach to the problem (Baron-Cohen, S., Wheelwright, S., Skinner, R., Martin, J., & Clubley, E. (2001)).

Recently, a study (see further details: Manning, C., Kilner, J., Neil, L., Karaminis, T., & Pellicano, E. (2017)) reported that *children with ASD update their behavior in response to changing environment which conflicts volatility theory*. This study showed no difference in behavior to a volatile environment between children with ASD, children without, and a neurotypical adult control group. Throughout the experiment, all groups were updating their learning at the same rate in different randomly volatile environments by weighting recent experiences more than distant ones. Although, it has to be noted that this study did not measure neurophysiological responses compared to the original study on volatility (Lawson, R. P., Mathys, C., & Rees, G. (2017)) to assess other types of responses to volatile environments, just choice and reaction times. The authors (Manning, C., Kilner, J., Neil, L., Karaminis, T., & Pellicano, E. (2017)) argue that a *Bayesian framework of volatility theory is successful in describing the process of sensory information in ASD, but it might not be so sufficient to address learning differences in ASD.* The article admits that for complex learning tasks and those with social predictors volatility theory seems to work, but it fails in simple learning tasks. This suggests that probably the nature of the specific task influences whether volatility theory is valid in the context. It might be that the present context is invalid for volatility theory if we consider blocking tasks as simple associative learning tasks. If we do so, it will result in a hypothesis that participants with ASD would not fixate on the blocking stimuli and show no blocking effect at all which is not entirely the case. Manning C. et al. 2017 introduced another factor for repetitive behavioral pattern which is anxiety level reported by parents of their children. They showed a correlation between anxiety level and behavior update in response to a volatile environment. It would be worth to test if this anxiety level correlates with blocking effect, so with difficulties in attention switching. This anxiety level could be further measured by heart rate data or saliva cortisol levels. Manning C. et al. also noted that the reward value fluctuation changed outcomes indicating that participants with ASD had a hard time to shift from an already accepted model if that seemed not working anymore under the new conditions. They address a speculation that maybe people with ASD would benefit from making slight changes from in their daily routine. However, they also make the point that to conclude something like this*; future research should compare different learning paradigms with the same sample of participants assessing individual differences as well, as I suggested in the previous paragraph.*

Conclusion

To sum up, the present study was made to assess differences in blocking mechanisms between children with ASD and without. However, the results showed no difference between the groups and no blocking effect in any of the groups. Further research is needed; first, to assess under which conditions a true blocking effect could be observed, and second, to assess individual differences in ASD by comparing different learning paradigms with the same sample of participants. It also seems necessary to change the present tradition of comparing neurotypicals and participants with ASD on the basis of diagnosis, as autistic traits are likely to be apparent in the whole population regardless of diagnosis (Baron-Cohen, S., Wheelwright, S., Skinner, R., Martin, J., & Clubley, E. (2001)). A better way would be to make correlation analyses of AQ (Autism Quotient) scores by identifying which ones are relevant for each specific hypothesis, or also ADI-R (Autism Diagnostic Interview-Revised) could be used in a similar manner and even anxiety level measures as additional factors.

Co-workership statement & Acknowledgement

This original idea for the present study comes from Joshua Charles Skewes. Formulation of the original idea for participants and the Research Ethics Committee of Region Midtjylland and the data collection was carried out by Joshua Charles Skewes, Line Gebauer, Rasmine Louise Holm Morgensen, Maja Hedegaard and Katrine Filtenborg. The present article, on the other hand, was written only by me, Blanka Sara Palfi as my Bachelor Project for Cognitive Science Bachelor programme at Aarhus University.

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