Article

autism

Autism
2014, Vol. 18(3) 264–271

DOI: 10.1177/1362361312472067
aut.sagepub.com
SAGE

Using Tic-Tac software to reduce anxiety-related behaviour in adults with autism and learning difficulties during waiting periods: A pilot study

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Abstract

Deficits in the perception of time and processing of changes across time are commonly observed in individuals with autism. This pilot study evaluated the efficacy of the use of the software tool Tic-Tac, designed to make time visual, in three adults with autism and learning difficulties. This research focused on applying the tool in waiting situations where the participants exhibited anxiety-related behaviour. The intervention followed a baseline and intervention (AB) design, and a partial interval recording procedure was used to code the presence of stereotypes, nervous utterances, wandering or other examples of nervousness during the selected waiting situations. The results showed that the use of Tic-Tac resulted in lower levels of anxiety-related behaviour in all three participants, compared to the baseline, suggesting that this software may be an effective technology for helping people with autism with organisation and predictability during waiting periods. The results are discussed in terms of limitations and implications for further study.

Keywords

anxiety-related behaviours, autism, technology, time perception

The difficulties encountered by people with autism spectrum disorders (ASD) in understanding the concept of time are well documented in the currently accepted descriptions of those disorders (Wing, 1996), educational practice (Peeters, 1997), and personal accounts of people with ASD (Joliffe et al., 1992). Lorna Wing (1996) considered a fundamental difficulty of ASD subjects to make sense of past and future experiences: 'The difficulties lie in comprehending the passage of time and linking it with ongoing activities' (p.88). Peeters (1997) talked about what he considers an essential component in autism, the difficulties in the 'experience of time':

> People with autism have difficulty 'going beyond the information', 'seeing beyond the literal'. So how can they understand what 'invisible time' is? People with autism have serious and understandable difficulties with this which cannot be explained only by a lower level of development. (p. 36)

This inability to understand and predict action structure and the passage of time may result in adhering to repetitive and structured routines and lead to the appearance of anxiety symptoms or challenging behaviour (Wing, 1996). Gillott (2004) suggests that adults with autism can present levels of anxiety three times greater than those without autism, while Waller and Furniss (2004) found a correlation between autism and anxiety disorders. Some authors have compared the rituals and repetitive behaviour commonly associated with autism to some of the frequent behaviour seen in obsessive–compulsive anxiety disorders (Bejerot, 2007). These anxiety symptoms can interfere with the educational and social interactions of the individual and may be identified and misinterpreted as 'behavioural problems'. Identifying anxiety in people with autism and learning difficulties is particularly complex due to their impaired communication skills, and consequently, it usually goes unnoticed by people around them (White et al., 2009).

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From the perspective of educational intervention, it is considered that underneath most of these challenging behaviour patterns, individuals with autism may have a general lack of understanding of key aspects of their life and, in particular, poor understanding of time. This was reflected on personal accounts of individuals with ASD:

> If someone says 'We may go shopping tomorrow' or 'We will see what happens', they do not seem to realise that the uncertainty causes a lot of inner distress (Joliffe et al., 1992; cited in Peeters, 1997)

Although deficits in time processing in autism have been well documented from a clinical viewpoint, it is only just beginning to be examined empirically (for a review, see Allman et al., 2012; Allman and Meck, 2012). Some research has focused on the study of time processing in ASD participants in periods lasting just a few seconds (Martin et al., 2010; Szelag et al., 2004; Wallace and Happé, 2008). Szelag et al. (2004) found that their participants with ASD were unable to repeat a short visual and/or auditory stimulus, in comparison to the control group. Martin et al. (2010) also reported evidence that high-functioning adults with ASD were less accurate in their reproduction of tones of varying durations. Allman et al. (2011) used a temporal bisection task of different magnitudes with autistic children, and they found a distortion in the time estimation, particularly in the longer anchor durations. Contrary to these findings, Wallace and Happé (2008) found no evidence of impairment in time reproduction tasks, although the methodological differences between the studies could explain the differing results.

Boucher (2001) and Boucher et al. (2007) investigated the capacity of children with ASD to represent and understand the changes that occur across time in wide temporal domains (hours, days, and so on.). They found that this group showed impairment in thinking diachronically, that is conceptualised as their individual ability to adopt a perspective of time both in their thinking and reasoning (Montangero, 1996). Through a series of well-controlled experimental situations, Boucher et al. (2007) studied the response of people with ASD to the three components of the diachronic thinking abilities: 'tendency', defined as the disposition to think forward or backward in time; 'transformation', that required the understanding that certain entities change qualitatively over time without losing their identity and 'synthesis', defined as the capacity to summarise a sequence of events in one event that represents all of them together. Boucher et al. (2007) found that people with ASD failed in this set of tests, and that none of the three features under study correlated with verbal and nonverbal levels.

However, it is not clear whether those difficulties in time processing in autism could emerge as a consequence of problems in other areas such as difficulties in episodic memory, a limited development of self-awareness or difficulties in representational abilities like those related to 'Theory of Mind' (ToM), all of them studied as possible prerequisites for time understanding in typical development by other researchers (composition from Hoerl and McCormack, 2001; Moore and Lemmon, 2001). However, time perception is a primordial ability shared by many species, with varying degrees, that do not always have ToM (Buhusi and Meck, 2005). It should also be considered that the ability to comprehend time, as suggested by some authors, indicated to be intact in some individuals with autism, such as the correct interpretation of clocks and calendars (Boucher et al., 2007; Wing, 1996), may also be impaired in the group that additionally presents learning difficulties.

We consider that the current knowledge about autism justifies the development of strategies and tools to favour the understanding of time, such as the 'Tic-Tac' software tool analysed in this study. Tic-Tac is a highly visual software application specifically designed to assist the understanding of time and time management for people with autism and/or learning difficulties (Herrera et al., 2009). There is recent evidence on the fact that the visual sense is the best preserved in ASD. For example, Kana et al. (2006) found that the processing of concepts that usually does not evoke visual images does activate the areas of parietal and occipital cortices in ASD, which are supposedly dedicated to visual processing. Similar results in this sense can be found in Gaffrey et al.'s (2007) study. In consonance with this, it was also observed in educational practice that most of the people with ASD are visual thinkers rather than verbal thinkers (Grandin, 1995; Jordan and Riding, 1995), and that the most common and extended programmes for intervention in ASD, such as Treatment and Education of Autistic and Communication related handicapped Children (TEACCH) (Mesibov and Howley, 2003) and picture exchange communication system (PECS) (Frost and Bondy, 2002), mostly use visually mediated learning and supports. The purpose of this pilot study is to evaluate the efficacy of the Tic-Tac software in reducing anxiety-related behaviour in participants with autism during waiting situations.

Method

Participants and settings

Three young individuals with ASD between 19 and 29 (two men and one woman) participated in the research. Participants were selected in a day centre for adults with ASD, following these criteria: (1) meeting the diagnostic criteria for autism in the *Diagnostic and Statistical Manual of Mental Disorders* (4th ed.; *DSM-IV*) (American Psychiatric Association (APA), 2000) and also those for learning difficulties (intellectual disability/mental retardation), (2) showing anxiety-related behaviours during waiting situations and (3) presenting difficulties in the

Table 1. Descriptive characteristics of the participants.

	William (participant 1)	Mary (participant 2)	John (participant 3)
Gender	Male	Female	Male
Age (in years)	29	19	26
Language	No verbal language	Uses a few words	No verbal language
Leiter: IQ	35	58	–
Leiter: mental age	4 years 6 months	6 years 8 months	0 years 7 months
Vineland: communication	11 months	11 months	9 months
Vineland: daily life abilities	3 years 8 months	2 years 6 months	1 years 10 months
Vineland: socialisation	9 months	2 months	2 months
Vineland: adaptive compound	1 year 9 months	1 year 2 months	11 months

understanding of time, an inability to learn how to use any conventional system for representing time before the study. Relevant details on the participants are included in Table 1. Their parents were informed about the procedure and future use of the collected data, and they signed a consent form. The names used in this article are not the participants' real names.

In the following paragraphs, we describe the anxiety-related behaviour showed by the participant during the selected waiting situations reported by the professional caregivers to be problematic:

Participant 1 was William, a 29-year-old male who showed anxiety-related behaviour when he was waiting for meals to be served in the dining room and when waiting for his gym class to start. He showed many stereotypical movements such as flapping his hands, rocking and repetitive behaviour such as sucking on cutlery, tapping the table and the wall, pouring water and so on, as well as nervous utterances (moaning and complaining).

Participant 2 was Mary, a 19-year-old female who showed most of her anxiety-related behaviour when waiting in her work room for lunchtime. Then, she refused to move, kept on working, paced around the room or showed stereotypies such as rocking and nervous utterances (echolalia, tongue clicking and so on)

Participant 3 was John, a 26-year-old male who showed anxiety-related behaviours waiting for his morning snack. His nervousness and stereotypies included flapping hands and arms, wandering around in the room, jumping and nervous utterances.

Procedure

A baseline and intervention (AB) design was used to assess the changes in the anxiety-related behaviour of the participants with ASD during the same waiting situations in both the baseline and intervention periods. Data were collected during the chosen situations during which the anxiety-related behaviours were observed. Notes for participant 1 (William) were made while he waited for his food sitting at the dining table and in the changing room, while waiting for his peers to finish their class. Notes of participant 2 (Mary) were taken in the work room while she waited for lunchtime. Finally, notes on participant 3 (John) were taken while he waited for his mid-morning snack in the leisure room. The same tutor (day centre staff) of each participant was present in the room during all phases of the study.

Baseline. For 2 months, the waiting situations identified as problematic were recorded by the day centre staff and analysed as described in the following. The tutors received instructions to act exactly in the same way as before the research study. No clocks or similar tools such as Tic-Tac were used during this baseline period.

Training. For one week, tutors taught the participants how Tic-Tac works (full details are provided in the next section). They first programmed the timers for very short periods (1 min) immediately followed by a reinforcement (i.e. a sweet) once finished. This was done with the intention of allowing participants to see the cause–effect relationship between the timer finishing and moving on to the next activity. During that week, the duration of the timers was gradually increased.

Intervention. During this 2-month stage, participants used Tic-Tac during the same waiting situations as were recorded during the baseline period. The tutor started the timer and then gave it to the participant. Tutors received instructions to intervene as little as possible, allowing the participants to be more autonomous when holding the tool.

Tic-Tac software tool

The Tic-Tac software consists of an alternative system for representing time in the short temporal domain (of seconds and minutes) making time visible, audible and tangible (with vibration), accompanying these representations with pictograms or pictures to identify the current activity or waiting period. In the visual mode, the passing of time passing is represented using decreasing or increasing bars, circles or the flow of sand through an hourglass (Figure 1). Almost all the options on Tic-Tac can be adapted to the

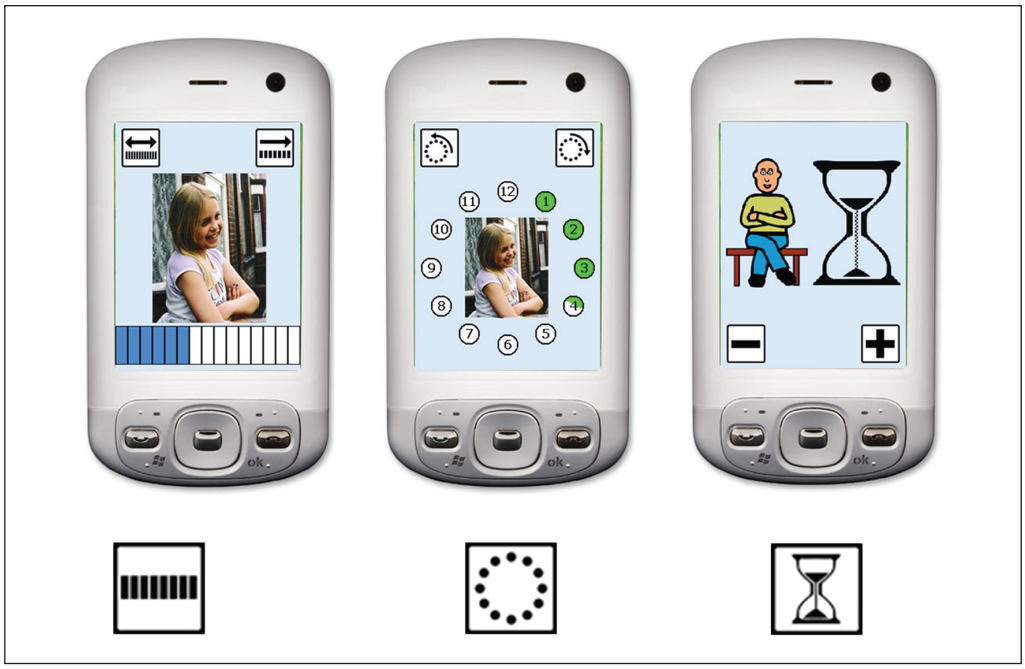

Figure 1. Samples of timers and launching pictograms.

individual preferences and situations: duration, the image to launch the timer, the sensory mode, the type of timer, colours and the accompanying image.

Tic-Tac software works on Smartphones, Tablets and Personal Computers with iOS, Android or Windows Operating Systems and belongs to a set of applications designed for people with ASD and learning difficulties that includes a PECS style communicator, a PECS style communicator, a photo album and an MP3 and video player. All these software applications can be downloaded free from a website in Polish, English, French and Spanish.

For this study, we selected the option of a visual timer with decreasing time bars for periods of less than 5 min. The device used was a Samsung Q1 Ultra with a 7 in touch screen sensitive to finger touch. None of the participants have used any similar device prior to this research nor have they used conventional sand hourglasses.

Measurement and behavioural definitions

The anxiety-related behaviour of the participants was considered as a set of dependent variables of the research, assessed using a combination of instruments and record sheets that are summarised in Table 2. In the first phase of this study, we asked the tutors (day centre staff) of the participants to complete a baseline questionnaire that included questions about the difficulties of the participants with ASD in processing and understanding time during waiting situations. After this, the day centre staff recorded the selected waiting situations, keeping enough distance to ensure that the presence of the camera had no effect on the behaviour of the participants, and completed a daily record sheet each time the selected waiting situations occurred, indicating the presence and severity of the anxiety-related behaviour. Furthermore, the staff and parents of each participant kept a communication notebook, noting the mood level, atypical behaviours and possible daily problems occurring during the day, at the day centre or at home. We also gained access to the records of the challenging behaviour functional analysis record, where the staff note down all serious challenging behaviour occurring at any moment of the day.

Table 2. List of instruments used during the research.

Instruments	Moments of use
Baseline questionnaire	Before the study
Record sheets	After each waiting situation
Video records	During waiting situations, randomly selected
Communication notebook ('travelling notebook')[a]	Every day
Challenging behaviour functional analysis record[a]	Only those days where challenging behaviour appears

[a]These two instruments have been in use at this day centre for over 10 years.

A total of 30 videos of waiting situations were randomly selected from different moments of the baseline and intervention periods, including waiting periods lasting from 3 to 10 min. Video recordings were analysed by two research team observers and two independent observers (two

Intervals of 15 seconds	15	30	45	1'	1' 15	1' 30	1' 45	2'	2' 15	2' 30	2' 45	3'	3' 15	3' 30	Sum	%
Stereotypies	x	x	x	x	x	x	x	x	x	x	x	x	x	x	14	100
Nervous Utterances		x			x	x			x		x		x	x	7	50
Wandering			x	x							x				3	21.43
Nervousness	x	x	x	x	x			x	x	x	x		x	x	11	78.57

Figure 2. Coding sheet sample.

Table 3. Description of coded variables.

Variables	Short description/example
Stereotypies	Participant shows some motor stereotypies, repetitive behaviours or makes movements that do not have a specific communicative purpose, such as mannerisms or touching certain objects
Nervous utterances	Participant makes noises or shapes with his or her mouth, which indicate nervousness and do not have a communicative function
Wandering	Participant is standing or moving around instead of waiting in the place where he or she is supposed to wait
Other examples of nervousness	Participant shows facial and body expressions indicating strain and nervousness

psychologists). Each observer visualised and coded all the videos using the partial interval recording procedure for both the baseline and intervention sessions. This type of recording is based on fragmenting every session into equal time segments (15 s) so if a target behaviour is present during a time interval, an 'x' is placed in the corresponding box on the record sheet (see Figure 2 for an example of coding sheet).

For each interval, observers were asked to code the following behaviours: stereotypies, nervous utterances, wandering and other examples of nervousness (descriptions are presented in Table 3).

Results and analysis

The following Figures 3 to 5 show the average scores across observers of each participant in each session and coding variable (stereotypies, nervous utterances, wandering and other examples of nervousness), in both the baseline and intervention periods. Data were summarised in terms of the percentage of total intervals during which the anxiety-related behaviours were present. Inter-observer agreement was measured with the Pearson quotient at 0.81 between internal and external observers.

All three participants demonstrated a reduction in their anxiety-related behaviours when Tic-Tac was introduced, although the level of improvement varied depending on the target behaviours. With regard to stereotypies, William (participant 1) and John (participant 3) showed a reduction of those behaviours. In the case of William, there was a reduction from the 78.16% of intervals with stereotypical behaviours in the baseline to 32.21% when using Tic-Tac. In the case of John, the percentage fell from 98.74% of intervals to a 67.36%. For participant 2, Mary, stereotypies were not so high at the baseline, and no considerable reduction was found (from 40.20% to 37.27%).

In terms of wandering and pacing, all three participants showed a reduction during intervention with Tic-Tac: William reduced his wandering intervals from 32.01% to 4.60%, Mary from 32.17% to 0.96% and John from 83.14% to 16.67%. The average percentage of nervous utterances also fell for all participants: William demonstrated a decrease in this behaviour from 29.56% of intervals to 8.9%, Mary showed a slight reduction from 22.59% to 19.62% and John from 44.53% to 21.25%. Finally, the other examples of nervousness also reduced during intervention with Tic-Tac, decreasing from 80.04% of intervals to 13.82% in William's case, from 48.86% to 23.65% for Mary and from 86.02% to 50.76% for John.

These results are consistent with those reflected on the record sheets for waiting situations completed by the tutors of the participants in both the baseline and intervention, where they scored on a 4-point Likert scale (none/mild/moderate/high) the level of anxiety-related behaviour shown by each participant in each waiting situation (Table 4).These percentages also demonstrated a reduction of the occurrence of anxiety-related behaviour from the baseline to the intervention with Tic-Tac.

No difference in the results was observed between longer and shorter waiting periods, meaning that the efficacy of the software was similar regardless of duration of use (from 3 to 10 min). In order to confirm that the anxiety-related behaviour was caused by the waiting situation and not by other factors, the communication notebooks and the functional analysis record were reviewed in detail. We found that only 3 of the 30 recorded and coded waiting

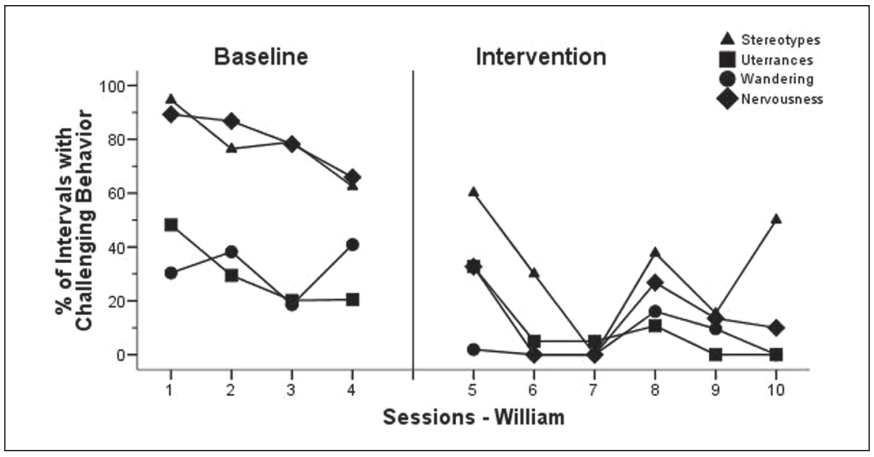

Figure 3. Graph corresponding to the scores of participant 1 (William) in each variable.

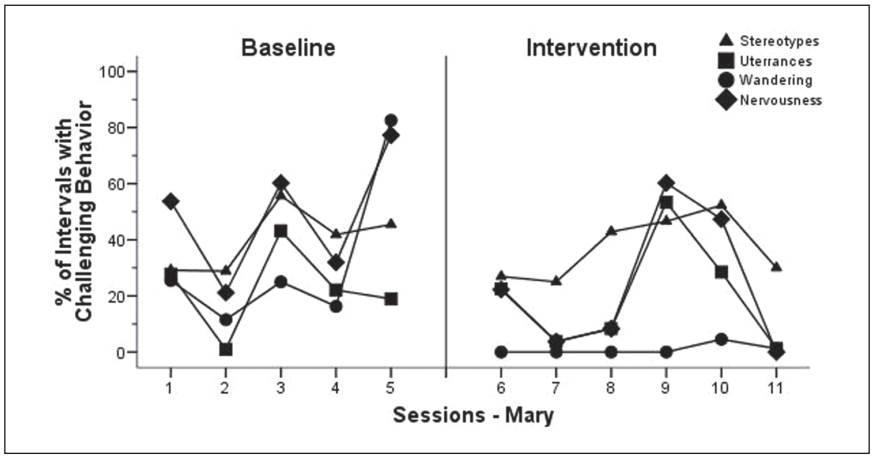

Figure 4. Graph corresponding to the scores of participant 2 (Mary) in each variable.

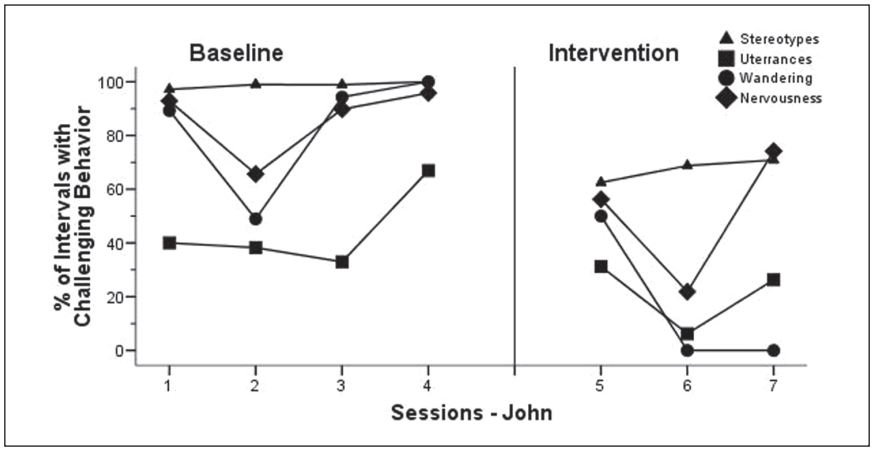

Figure 5. Graph corresponding to the scores of participant 3 (John).

situations might have been caused by previous nervousness or discomfort of the participant during the day in which the waiting situation occurred. The level of support provided by each tutor was also examined in order to ensure that there were no differences in the support provided in the baseline and intervention periods.

Table 4. Percentage of none, mild and moderate–high anxiety-related behaviour in waiting situations across the baseline and intervention according to record sheets.

	Participant 1		Participant 2		Participant 3	
	Baseline	Intervention	Baseline	Intervention	Baseline	Intervention
None (%)	21.05	66.67	33.33	91.30	8.33	65
Mild (%)	31.58	30	52.38	8.70	33.33	30
Moderate–high (%)	47.37	3.33	14.29	0	58.33	5

Discussion

The results of this study showed that signalling the duration of a wait period with the Tic-Tac software tool reduces anxiety-related behaviour in three adults with autism and learning difficulties. Tic-Tac presents a visual format of time information that is more meaningful than verbal instructions or conventional timers, helping the participants to predict the duration of short waiting periods. All three participants displayed less stereotypies, nervous utterances, wandering and other examples of nervousness.

However, a limitation of the AB design of this study is that the order of the baseline and intervention was not counterbalanced between participants, suggesting that additional research would be necessary to prove the efficacy of the Tic-Tac software. Another limitation of this research is that the use of Tic-Tac needs to be compared with other visual aids. Several strategies have been used with participants with ASD during transitions from one activity to another, including visual schedules, photographic cues or line drawings, providing predictability and reducing challenging behaviour (Dettmer et al., 2000; Hodgdon, 1995; MacDuff et al., 1993). Further research is needed in order to compare the efficacy of these different visual supports.

Interestingly, the video recordings allowed us to observe that William and Mary pointed to the timer with their fingers and even touched the Tic-Tac screen following the time bars during the waiting sessions. They also perfectly understood the consequence of the decreasing time bars because they immediately moved to the next activity when the waiting period was complete. For John, although the comprehension of the relationship between time and the decreasing time bars was not as consistent, the tutors nevertheless observed an improvement in his understanding of the software during the subsequent months of intervention (these results are not included in this study).

However, the decrease in anxiety-related behaviours was limited to the waiting situation where the Tic-Tac was applied. This is not surprising if we consider the well-known difficulties presented by people with autism for generalisation (Handleman and Harris, 1980). Therefore, for these participants, it would be necessary to work separately on each problematic situation, as it is advisable to work with people with autism (Jordan and Riding, 1995). For longer waiting periods, it is also important to take into account the well-known monotropic processing presented in autism (Bogdashina, 2003, 2005; Murray, 1997). For ethical concerns, we should develop strategies for avoiding situations where the participants pay attention to the same stimulus for more than 5 min, as waiting situations can sometimes last for several hours. In order to prevent them focusing their attention exclusively on the Tic-Tac during long waiting situations, a possible solution would be to limit the number of time that the individual with autism can observe the timer and provide alternative activities during those waiting situations. Future study will concentrate on testing Tic-Tac in other situations where it is necessary to predict the period of time, for example, in working or educational situations, leisure situations or times of sensory overload. Without a doubt, the extended use of this tool in other challenging waiting situations can potentially have a strong impact on the participants' quality of life.

The present study demonstrates the positive impact of Tic-Tac with three participants with autism and justifies further study using bigger sample groups and different levels of abilities. These findings also support future technological development study in order to create new tools to facilitate the organisation and predictability of broader temporal domains such as days, weeks or years.

Acknowledgements

This research has been fostered by Orange Foundation (Spain) and the Spanish Ministry for Industry, Commerce and Tourism, through Avanza Program. We would like to thank the participants of this research from whom we have learned so much. We would also like to thank the families and the professionals that collaborated in this research, especially Román Izquierdo, Raquel López, Begoña Martínez and Fátima Martínez. We will also like to thank to Dr Rita Jordan, University of Birmingham, for her advice and help.

Funding

This study was supported by the Orange Foundation in Spain and the Spanish Ministry for Industry, Commerce and Tourism (grant number PDM-2006-010) through Avanza Program.

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