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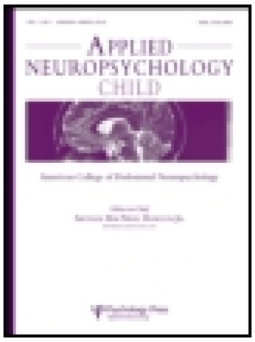

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Psychometric properties of the Children's Time Awareness Questionnaire (CTAQ): A study on the validity of a Dutch 20-item questionnaire measuring time awareness in children

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ABSTRACT

This study investigates the validity of Children's Time Awareness Questionnaire (CTAQ), a 20-item task for assessing children's time awareness. The CTAQ was administered to a group of typically developing children ($n = 107$) and children with any developmental problems reported by parents (non-typically developing children, $n = 28$), aged 4–8 years old. We found some support for a one-factor structure (EFA), yet the explained variance is relatively low (21%). Our proposed structure of two additional subscales, i.e., "time words" and "time estimation," was not supported by (confirmatory and exploratory) factor analyses. In contrast, exploratory factor analyses (EFA) indicated a six-factor structure, which needs further investigation. We found low, yet non-significant correlations between CTAQ scales and caregiver reports on children's time awareness, planning and impulsivity, and no significant correlations between CTAQ scales and scores on cognitive performance tasks. As expected, we found that older children have higher CTAQ scores than younger children. Non typically developing children had lower scores on CTAQ scales, compared to typically developing children. The CTAQ has sufficient internal consistency. The CTAQ has potential to measure time awareness, future research is indicated to further develop the CTAQ and enhance clinical applicability.

KEYWORDS
Children; development; timing; time awareness; psychometric properties

Introduction

Recent years show an increased interest in exploring individual differences in children's time awareness (Marx et al., 2020; Labrell et al., 2020). Time awareness, also referred to as time perception, timing, or temporal processing, is believed to facilitate our ability to predict, anticipate, and respond competently to daily life and contribute to the development of children's independence in daily living (Barkley, 1997b; Janeslätt, 2009; Piaget, 2013). Some children can learn to tell time from a clock but are unable to use this information in their everyday lives: they experience difficulties in time awareness and have problems with planning, with using familiar routines and with anticipating, because, for example, they are less able to estimate how much time daily activities take (Janeslätt, 2009). As such, deficits in time awareness may have a major influence on daily functioning of children.

Time awareness is a complex concept and several cognitive functions are believed to be essential for successful time awareness (Block & Zakay, 1997; Wearden, 2003). A good "internal clock" or timer, working memory, attentional processes, self-control, and self-monitoring are examples of cognitive functions that are believed to be part of time awareness (Block & Zakay, 1997; Wearden, 2003). Good verbal abilities (such as vocabulary) also contribute to a better time awareness (Droit-Volet & Zélanti, 2013; Wearden, 2003).

Previous studies indicated that time estimation and orderings of time words are two different concepts that show separate developmental trajectories in children (Tillman & Barner, 2015). Literature concerning the development of time awareness indicates that a basic level of time awareness (recognition of patterns in time) is already present in infants (Droit-Volet, 2013; Fitzgerald et al., 1967). Concerning time words, children first seem to learn time words like "before" and "after," followed by an understanding of the ordering of these time words (sequence, patterns, and orders), and finally the ability to estimate the duration of an event (Tillman & Barner, 2015; Tillman et al., 2018). Previous studies on the development of time words, found that, for instance, around the age of four to six years children first develop a certain sense of time in daily activities, e.g. "Do you eat lunch before or after breakfast?" Around

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the age of 8 years the child can order the days of the weeks and months and from about the age of 15 years, adolescents are able to tell, for example, which month is three months before September, without mentally reciting the months (Friedman, 1986). Thus, the development of time awareness consists of two different trajectories: knowledge on time words on the one hand and the ability to estimate time on the other, and both trajectories improve when children grow older.

With respect to sex, research has shown for instance better time awareness in adult men than in women (Bartholomew et al., 2015; Hancock & Rausch, 2010). In contrast, the few studies available including children did not find sex differences in time awareness (Droit-Volet, 2003; Friedman, 1986).

Previous studies found that children with diverse developmental problems (e.g., Attention Deficit Hyperactivity Disorder (ADHD, (Ptacek et al., 2019), Autism Spectrum Disorder (ASD) (Isaksson et al., 2018), reading problems (Casini et al., 2018), mathematical problems (Pellerone, 2013)) show lower scores on performance tests measuring time awareness. Most of these studies investigate only time estimation as opposed to time words. Performance tasks measuring time estimation, time production, or time reproduction are frequently used in studies to assess time awareness in children (for an overview, see (Block et al., 1999)).

In time estimation tasks, children are asked, for example, to tell how long a stimulus was shown on a computer screen. In time production tasks and time reproduction tasks, children are asked, for example, to press the space button for either an indicated number of seconds or for the same period of seconds that a stimulus was shown. These (mostly computerized) tasks often measure time spans of milliseconds to minutes. Because of the short time spans and the lack of context in tasks like these, the implication of test scores to daily life challenges remains unclear and the ecological validity is thought to be low (Schmuckler, 2001). Ecological validity is defined as "the extent to which one can generalize from observed behavior in the laboratory to behavior in the world" (Schmuckler, 2001) and is presumed to be of importance in measuring time awareness in children.

The Children's Time Awareness Questionnaire (CTAQ) is developed in the Netherlands as a performance task, with questions to be answered by children themselves. Only a Dutch version has currently been developed. In contrast to tasks mentioned previously, the children must estimate longer time durations and the time duration of daily activities familiar to them. More concretely, children are asked to answer 20 questions on time words (e.g., what lasts longer an hour or a minute?) and time durations—here, the child is asked to verbally estimate the time duration of events familiar to him or her (e.g., how much time does it take to inflate a balloon?). Based on these items, one CTAQ total score scale is calculated as well as scores on two subscales: (1) a CTAQ subscale measuring one's ability to understand the lengths and relative orders of two time words (this subscale is called CTAQ time words), and (2) a CTAQ scale measuring one's ability to estimate time duration (i.e., the subscale CTAQ time estimation). We assume that the inclusion of familiar daily events and situations adds context to the questions asked, which makes the CTAQ a more ecologically valid instrument for measuring time awareness in children than the above-mentioned computerized tasks.

The main aim of our study was to investigate the validity of the CTAQ in children between age 4 and 8. Thus far, no data were available on the psychometric properties of the CTAQ subscales time estimation and time words for children aged 4–8. In a previous study, CTAQ was applied to investigate differential development of time awareness, including children from the age of 5 and adults (Wassenberg, 2007). Significant correlations between the time estimation questions of CTAQ and the time estimation questions of the Biber Cognitive Estimation Test (BCET) were found (Bullard et al., 2004) in 150 typically developing children (aged five to eleven, $\rho = .43$, $p < .001$) and in a group of 82 children with and without ADHD (both groups $N = 41$, aged six to twelve, $\rho = 0.52$, $p < .001$). Also, a significant correlation was found between score on the time estimation questions of CTAQ and performance on a computerized task of time estimation (sample with 41 ADHD and 41 typically developing children, $\rho = -0.49$, $p < .001$). We chose the age range specifically, since significant changes in the development of time awareness are believed to take place in this age interval (Tillman et al 2018). To our knowledge, no ecologically valid instrument is currently available that measures time awareness in children this young. First, we conducted confirmatory factor analyses (CFA) to investigate the validity of the proposed factorial structure of the CTAQ. Here, we hypothesize that the CTAQ is composed of two factors, i.e., time words and time estimation. Then we conducted exploratory factor analyses (EFA) to further investigate the factorial structure.

Next, we investigated the validity of the CTAQ for these young children in five ways. First, we examined intercorrelations between the two subscales of the CTAQ. We expected moderate correlations between the two CTAQ subscales in these young children, because of the differential development of time awareness. Knowledge on time words on the one hand, and the ability to estimate time on the other, are two unique yet related aspects of time awareness (Wearden, 2003).

Second, we studied the correlations between the CTAQ subscales and a caregiver-report measuring time awareness in children, the Five to Fifteen (Kadesjö et al., 2004).

Method

Participants

Caregivers of all children enrolled in six Dutch schools (kindergarten and elementary school grades 1 to 4, in the southern parts—i.e., the Noord-Brabant region- of the Netherlands) were asked to participate in this study. Caregivers of 143 children gave informed consent. Of these children, 139 children had the Dutch nationality, 2 children were Polish, 1 child was Portuguese, and 1 child was

Rumanian. Two (one child with the Polish nationality and one child with Rumanian nationality) of these four children were excluded: their understanding and speaking of the Dutch language was insufficient for the administration of the instruments we used. We did not collect data on ethnicity, because ethnicity-based norms are not available for the instruments we used. Information about development (typical/non-typical) was missing for one participant, therefore this participant was excluded. Of 5 children, the data on the CTAQ were missing. Therefore, they were excluded. Our sample consists of 135 children (73 boys), aged 4–8 years ($M = 6.4$, SD = 1.4). In total, for 28 children, caregivers reported developmental problems, such as attentional problems, reading problems or ADHD. As mentioned above, previous studies found that children with diverse developmental problems, obtain lower scores on time awareness measurements. Our sample is also a heterogenous group of children. Because of the small sample size, we decided not to create subgroups within this sample. See Table 1 for a precise description of the group of non-typically developing children. Caregivers were asked to indicate what the level is at which they have received education (also known as Level of Parental education or LPE). We included the LPE of the caregiver with the highest level of education (in line with e.g., Kalff et al., 2001): 6 families (4.4%) had a low level of education (elementary school or lower vocational education), 41 families (30.3%) had a middle level of education (secondary general education or secondary vocational education), and 83 families (61.5%) had a high level of education (higher professional education or university degree). Five families did not provide reports on their level of education.

Procedure

Together with the information letter and the informed consent form, caregivers received a questionnaire via the children's school. Via the questionnaire we asked parents to provide information about demographics (e.g., the child's age, sex, developmental disorders, concerns about behavior or development), their children's time awareness (Five to Fifteen), and related cognitive abilities (Five to Fifteen and BRIEF). Once filled out by parents, the informed consents and questionnaires were returned to us via the school. Well-trained research assistants administered the performance tests mentioned below as part of a larger test battery. Testing took place in a one-on-one setting in a room at the children's school. We asked the schools to select a room that was as quiet as possible, in order to limit distraction as much as possible. The study was approved by the Medical Ethical Board of Kempenhaeghe, Heeze, the Netherlands and the ethics committee of the Faculty of Psychology and Neuroscience, Maastricht University, Maastricht, the Netherlands.

Materials

Children's Time Awareness Questionnaire (CTAQ)

The items were based on literature of time awareness in children. The subscale CTAQ time estimation includes 11 open-ended questions in which children had to estimate the duration of an event (Hendriksen & Hurks, 2004; Peijnenborgh, 2016; Wassenberg, 2007). There is no exact answer to these questions. To score the open-ended questions, all answers that fell between the 5th and 96th percentile (as was done in an adult sample ($N = 246$) using CTAQ by Wassenberg (2007) and in line with e.g., Bullard et al. (2004) were scored as 1 (correct), whereas scores outside this range were scored as 0 (incorrect). The second subscale, CTAQ time words, measures the understanding and ordering of time words, based on 8 items asking participants to compare two time words and to indicate which word refers to the longest time interval. These items were scored as 0 (incorrect) or 1 (correct). Finally, the total score scale of the CTAQ is the summation of scores on 20 items: the items of the two subscales plus one additional item. This one additional item (i.e., which takes longer: a movie or an episode of Sesame Street?) was not included in any of the subscales. It conceptually seemed to address both time words and time estimation (since it asks for both an estimation of the duration of the two activities and the ability to compare this duration to one another). The instruction and the items of the CTAQ were originally developed for children enrolled in elementary schools. Given the very young age of the children who participated in our study, the researcher read out

Table 1. Description of the sample of atypically developing children.

	Frequency	Percent
1. Autism	5	17.85
2. Autism and ADHD	3	10.71
3. ADHD	2	7.14
4. Autism, suspected ADHD	2	7.14
5. Anxiety problems	2	7.14
6. Post traumatic stress disorder	2	7.14
7. ADHD, Autism and motor problems	1	3.57
8. Autism, suspected anxiety problems	1	3.57
9. Autism, reading problems and anxiety problems	1	3.57
10. Sensorimotor integration problems, mood disorder and autism	1	3.57
11. Autism, suspected dyspraxia	1	3.57
12. Mood disorder	1	3.57
13. Attachment disorder	1	3.57
14. Short attention span	1	3.57
15. Mathematical problems	1	3.57
16. Reading problems	1	3.57
17. Suspected social/emotional problems	1	3.57

all items of the CTAQ to the children and children were asked to respond verbally. Higher scores on the CTAQ indicate better time awareness performance.

Five to Fifteen (FTF)

This caregiver questionnaire contains questions on developmental and behavioral problems. Five FTF subscales were administered in this study: (1) Time concepts, (2) Attention, (3) Hyperactive/Impulsive, (4) Planning and organization and (5) Social skills. Raw subscale scores range from 3 to 135, higher scores indicate more problems. Cronbach's α for these subscales were between 0.69 and 0.90 (Kadesjö et al., 2004).

Behavior Rating Inventory of Executive Function (BRIEF)

The BRIEF (Gioia et al., 2000) is a 75-item questionnaire, filled out by caregivers. Questions concern caregivers' evaluation of their child's cognitive functioning. Of the nine subscales, raw scores on the subscales Emotional Regulation, Working Memory, Inhibition, and Flexibility were included in the study. The higher the score on a (sub-)scale, the more problems exist. Subscale scores range from 8 to 30. Cronbach's α for the subscales used are >0.80 (Gioia et al., 2000).

Verbal Fluency

Verbal Fluency is a widely used test to measure verbal functioning, and executive functioning (Lezak et al., 2004; Vaucheret Paz et al., 2020). Here, the children were asked to state as many types of animals as they can within one minute. Total score is the number of correct responses minus the number of repeated responses (e.g., if a child mentions an animal twice) (Lezak et al., 2004). Test-retest reliability of this type of test is sufficient ($r = 0.68$) (Harrison et al., 2000).

Digit Span Forward

Digit Span Forward is a subtest of Wechsler Intelligence Scale for Children III, Dutch version (Kort et al., 2002) and measures short term auditory memory in children. The outcome measure included is the total number of correctly recalled series. Raw scores range from 0 to 16. Guttmann's lambda-2 (λ-2) coefficients, as a measure for reliability, is between 0.81 and 0.89 (Kort et al., 2002).

Vocabulary

Vocabulary is a subtest of Wechsler Preschool and Primary Scale of Intelligence, Dutch version (Hendriksen & Hurks, 2009). It measures word knowledge and verbal concept formation. In the first part of the test (which is only used for children under the age of 4), the child names pictures that are displayed in a stimulus book (5 items). In the second part, the child gives definitions for words that the examiner reads aloud (20 items). We included raw scores, which range from 0 to 45 (i.e., the higher the score, the better the performance). Cronbach's α for this subtest is between 0.71 and 0.82 (Hendriksen & Hurks, 2009).

Transparency and openness

All data, analysis code, and research materials are available by emailing the corresponding author, and via Open Science Framework (OSF).

Statistics

We studied structural validity by investigating the model fit of the 2-factor model of CTAQ (consisting of the time words scale and the time estimation scale), with Confirmatory Factor Analyses (CFA). To determine the fit of the model, we studied the following fit measures: Root Mean Square Error of Approximation (RMSEA), Goodness of Fit Index (GFI), Comparative Fit Index (CFI), and Tucker Lewis Index (TLI). The RMSEA values less than 0.05 are good, values between 0.05 and 0.08 are acceptable, values between 0.08 and 0.1 are marginal, and values greater than 0.1 are poor (Fabrigar et al., 1999). A GFI value of 0.9 or higher is believed to be acceptable (Bentler, 1990). Furthermore, the CFI and TLI value, should be over 0.9 for a good fit (Bentler, 1990). We also performed Exploratory Factor Analysis, by studying the Kaiser–Meyer–Olkin Measure of Sampling Adequacy (KMO values <0.50 are insufficient, >0.60 are mediocre, >0.70 are middling, 80 are meritorious, and KMO values of >0.90 are marvelous, Kaiser & Rice, 1974) and we computed Bartlett's Test of Sphericity. Validity was further assessed in five different ways:

1. intercorrelations of CTAQ (sub)scale scores,
2. by calculating correlations (Pearson) between CTAQ scores to scores on caregiver reports measuring time awareness measures, We expected to find high correlations (>0.70, Cohen, 2013)) between the CTAQ subscales and caregiver reports on time awareness, because the same over-arching construct (time awareness) is measured, even though the informants differ between these tests (caregiver versus the child).
3. by calculating correlations between CTAQ scores to questionnaires and performances on tasks measuring cognitive functions related to time awareness. We consider these analyses to be explorative: Currently, no studies exist into the association between cognitive measures and separate constructs measured by CTAQ subscales. The subscales each measure a different aspect of time awareness, however for both cognitive functions, such as verbal abilities and working memory, are believed to be needed (in line with e.g., Wassenberg, 2007 and (Brenner et al., 2015). The influence of these cognitive functions may differ for each CTAQ subscale. We expected to find moderate correlations (0.50–0.70) between all CTAQ scores and caregiver reports and scores on performance tests assessing these cognitive functions. The size of all correlations was evaluated

according to Cohen et al.'s (2013) guidelines: 0.10 is small, 0.30 is medium and 0.50 is large.

4. By evaluating the impact of demographic variables ("sex," "age" and "typical versus non-typical development" on CTAQ-scores, based on previous studies that also found an impact of these demographic variables on time awareness (Droit-Volet & Zélanti, 2013), we expected to detect no sex differences in our sample of young children (in line with Droit-Volet, 2003). Furthermore, based on studies mentioned before, we expected to detect age differences in our sample of young children, with older children performing better than younger children. Studies mentioned before showed that when comparing the development of time estimation of typically developing children to development of non-typically developing children (such as children with ADHD (Ptacek et al., 2019) or learning disabilities (Casini et al., 2018, Pellerone, 2013), the scores of non-typically developing children indicated a slower development of time awareness. We expected that children with a non-typical development perform on average less well than typically developing children on all CTAQ scales, even at a young age.

We used a regression-based procedure to investigate the impact of these demographic variables. Compared to e.g., ANCOVA, these regression analyses provides information the impact of each of the demographic variables included as well as of the combination (or interaction) of these demographic variables (Plonsky & Oswald, 2017). Before running these analyses, the assumptions of such regression analyses were tested by conducting a Kolmogorov–Smirnov test (to evaluate the normality of the residuals), by applying the Levene's test (to evaluate homoscedasticity), by calculating Variance Inflation Factors (VIFs) and condition indices (to identify multicollinearity), and by computing Cook's distances (to identify influential cases). The assumptions were all met. CTAQ total scale score and subscales were included as dependent variables in the multiple regression analyses. Independent variables included were demographic variables sex (coded 0 = boy and 1 = girl) and having a typical vs. non-typical development (coded 0 = typical development and 1 = non-typical development, coding was conducted in line with Evers et al., 2009. Age was included as a continuous factor. Two-way interactions between age, age^2, sex and typical vs non-typical development were included in the full regression model (in line with e.g., Van der Elst et al., 2011). Then the model was reduced by a stepwise procedure, excluding the non-significant interactions and factors one by one.

Finally, Guttmann's lambda-2 (λ-2) coefficients were calculated for the CTAQ total score scale and both subscales, to obtain an indication on the reliability of the CTAQ. λ-2 coefficients can be interpreted in the same way as Cronbach's alpha, yet λ-2 coefficients are believed to be more robust, giving a more accurate measure of reliability—Cronbach's alpha is known to be a lower bound measure for reliability (Evers et al., 2009). λ-2 coefficient of the CTAQ is believed to be insufficient when it is <0.70, sufficient when it is $0.70 \leq r < 0.80$, and good when it is ≥ 0.80 (Evers et al., 2010).

Data were analyzed with IBM SPSS statistics version 25. For Confirmatory Factor Analyses (CFA) we used the R-based software program Jamovi.

Results

Validity

Structural validity

The RMSEA value is 0.051 for our sample, which indicates an acceptable fit (Fabrigar et al., 1999). The GFI value is χ^2=204, which is believed to be acceptable (Bentler, 1990). Furthermore, the CFI value is a little below the criterium of 0.9 (i.e. .85) which shows a relatively good fit (Bentler, 1990). The other fit index, TLI, should be over 0.9 for a good fit (Bentler, 1990). In our sample, the TLI is below the criterium (TLI = 0.83). We repeated the CFA, including this one item as an unique factor, but that did not improve model fit, also repeating CFA on a one factor model did not improve model fit. The results of the CFA (two factor model) are listed in Table 2. EFA did not confirm the proposed two-factor structure either: The Kaiser–Meyer–Olkin Measure of Sampling Adequacy and Bartlett's Test of Sphericity were used to assess the suitability of the data for factor analysis. EFA was first performed with Varimax Rotation, using minimal factor loading of 0.50. After stepwise exclusion of the factors with a factor loading <0.50, we found a six-factor model, explaining 60.2% of the variance. Factor loadings for this EFA are listed in Table 3. Additionally, we performed an EFA enforcing two-factor structure in order to test the proposed structure of the CTAQ. Factor loadings were low for 12 of the 20 items. When enforcing a one-factor structure, factor loadings for 19 out of 20 items were acceptable (>0.30), however, the total variance explained was only 21%.

Table 2. Factor loadings of confirmatory factor analysis (two-factor model).

	Unstandardizes estimates	Standardized estimates
Factor time words		
1. Item 3	0.28 (0.05)	0.60
2. Item 8	0.22 (0.04)	0.62
3. Item 10	0.12 (0.05)	0.24
4. Item 11	0.13 (0.04)	0.30
5. Item 14	0.09 (0.04)	0.23
6. Item 17	0.13 (0.05)	0.29
7. Item 18	0.17 (0.05)	0.34
8. Item 19	0.22 (0.04)	0.57
Factor time estimation		
1. Item 2	0.17 (0.05)	0.34
2. Item 4	0.27 (0.04)	0.57
3. Item 5	0.06 (0.04)	0.15
4. Item 6	0.31 (0.04)	0.63
5. Item 7	0.22 (0.04)	0.44
6. Item 9	0.23 (0.04)	0.49
7. Item 12	0.18 (0.04)	0.40
8. Item 13	0.16 (0.05)	0.33
9. Item 15	0.36 (0.04)	0.74
10. Item 16	0.29 (0.04)	0.58
11. Item 20	0.12 (0.04)	0.28

Values in parentheses were standard errors for estimates.

Intercorrelations between CTAQ subscales

The correlation between the two subscales was positive and large. All correlations are listed in Table 4. Results are partly in line with our expectations: because of the separate development of time words and time estimation we expected to find moderate correlations instead of large correlations.

Correlations between CTAQ scales and caregiver reports

When corrected for age, the correlations between the CTAQ subscales and caregiver reports were no longer significant, see Table 5.

Correlations CTAQ scales and performance tests

When corrected for age, the correlations between CTAQ subscales and performance tests were no longer significant, see Table 6.

Table 3. Factor loadings: exploratory factor analysis, 6 factors found.

	Factors 1	2	3	4	5	6
Item 2					−0.55	
Item 3			0.82			
Item 4		0.68				
Item 5				0.60		
Item 6	0.53					
Item 8			0.84			
Item 9	0.71					
Item 10						0.82
Item 12	0.69					
Item 13				0.63		
Item 14		0.73				
Item 15	0.52					
Item 16	0.72					
Item 17					0.73	
Item 18		0.54				
Item 19			0.58			
Item 20				0.74		

Rotated component matrix. Extraction method: principal components analysis. Rotation method: Varimax with Kaiser normalization.

Table 4. The CTAQ scales: intercorrelations between CTAQ subscales for the whole sample.

	1.	2.	Mean	SD.
1. CTAQ time words	–		5.81	1.75
2. CTAQ time estimation	0.51**	–	4.73	2.75

**Correlation is significant at the 0.01 level,. *Abbreviations*: CTAQ: Children's Time Awareness Questionnaire.

Relation between CTAQ scores and sex, age, and development

Multiple regression analyses were run. None of the interactions contributed to the models. The variable "sex" was not associated with CTAQ subscales. As expected, age and whether a child has a typical development (Yes/No) were associated with CTAQ total score and CTAQ subscales. Younger children obtained lower scores on all CTAQ subscales. Also, children with a non-typical development have lower scores on all three CTAQ subscales than children with typical development (Table 7).

Reliability

Internal consistency was sufficient for the CTAQ total score scale (λ-2 = 0.79) and for the CTAQ time estimation subscale (λ-2 = 0.75), but insufficient for the CTAQ time words subscale (λ-2 = 0.59).

Discussion

The aim of the present study was to do a pilot study on the validity of the CTAQ, a 20-item Dutch performance task that aims to quantify time awareness, in young children. Here, children were asked about daily events and situations that are familiar to them. As mentioned in the introduction,

Table 6. The CTAQ scales: correlations between CATQ and performance tests.

	CTAQ total	CTAQ time words	CTAQ time estimation	Mean	SD
1. Verbal fluency	0.13	0.11	0.91	9.8	4.22
2. Digit span	0.14	0.07	0.14	6.2	2.2
3. Vocabulary	0.18	0.15	0.14	21.8	7.0

Abbreviations: CTAQ: Children's Time Awareness Questionnaire.

Table 7. Final multiple linear regression models for the CTAQ measures that resulted from a step-down hierarchical procedure.

	t	*p*	*β*	*F*	*df*	*p*	Adj R^2
CTAQ total				68.21	2	.001	0.51
• Development	−3.91	.00	−0.25				
• Age	11.68	.00	0.75				
CTAQ time words				32.24	2	.001	0.32
• Development	−3.57	.000	−0.27				
• Age	7.95	.000	0.60				
CTAQ time estimation				50.90	2	.001	0.43
• Development	−2.90	.004	0.47				
• Age	10.09	.000	0.14				

Table 5. correlations between CTAQ and caregiver reports corrected for age, for the whole sample.

	CTAQ total score	CTAQ time words	CTAQ time estimation	Mean	SD
12. BRIEF emotional regulation	−0.12	−12	−0.76	15.06	4.89
13. BRIEF working memory	−31	−0.36	−0.24	15.37	4.99
14. BRIEF inhibition	0.06	0.09	−0.12	14.82	4.90
15. BRIEF flexibility	−0.14	−0.13	−0.090	11.49	3.20
16. Five to Fifteen Time	−0.27	−0.25	−0.20.0	10.35	2.57
17. Five to Fifteen planning	−0.28	−0.25	−0.210	7.40	2.41
18. Five to Fifteen attention	−0.34	−0.27	−0.28	21.36	5.38
19. Five to Fifteen impulsivity	−0.24	−0.27	−0.17	31.28	7.87
20. Five to Fifteen social	−0.24	−0.24	−0.18	53.88	14.56

Abbreviations: CTAQ: Children's Time Awareness Questionnaire.

we started by conducting (both confirmatory and exploratory) factor analyses to investigate a proposed two factor structure underlying the subscales time words and time estimation. Then, we studied the validity of the CTAQ in 5 additional ways, e.g., via correlations with other tests or subscales measuring time awareness and/or related constructs, correlations with demographic variables, such as age and sex, and by studying differences among groups (non-typically developing children versus controls).

Despite the theoretical underpinnings for the two-factor structure and relatively good fit indices of the confirmatory factor analyses, the factor loadings were overall low due to which we were unable to find sufficient support for this model through factor analyses. A one-factor model does not seem to fully reflect the complexity of the concept time awareness. A six-factor structure indicated to have a better model fit, yet this model needs further investigation. We recommend that for future research, adding a number of items per factor could be considered, followed by investigating the psychometric properties in a larger sample and by including a wider age range. Challenges concerning the factor structure of the CTAQ may also be related to some of our other findings, such as the relatively weak correlations between CATQ subscale scores and cognitive functions. We expected to find associations between the concept of time awareness as measured by CTAQ and cognitive functions associated with time awareness measured by CTAQ. For example, the correlations between CTAQ scores and verbal abilities were not significant, contrary to our expectations. This could be related to the underlying factor structure. However, other studies have shown, that verbal abilities are associated with the development of time awareness (Droit-Volet & Zélanti, 2013; Wearden, 2003). It would also be interesting to investigate this association by comparing CTAQ scores to other measures of verbal abilities, e.g., other subtests of the Verbal Comprehension Index of the WISC V to study divergent validity. Another interesting possibility is to add non-verbal items or items that have a less strong verbal component to the CTAQ. A next interesting step for future research into the validity of CTAQ, would be to investigate the associations between CTAQ subscales and other frequently used measures on time awareness, such as laboratory tests on time production and time reproduction.

Results, that are in line with our hypotheses, provide some support for validity of the CTAQ to measure time awareness in young children. For example, when examining which factors can predict CTAQ performances, we found, as expected, that the age of a child and having a non-typical development are associated with scores on all CTAQ scales: older children, in generally, have better time awareness than younger children and children with a typical development have a better time awareness than children with an a-typical development, measured by CTAQ. This is indicative for adequate construct validity, and is in line with previous research, which also found developmental differences in time awareness (Block et al., 1999; Droit-Volet, 2013; Tillman et al., 2018). Children with a non-typical development have lower scores on all three CTAQ scales than children with typical development—which is also in line with our hypotheses. Several studies including older children indicated for instance a relation between time awareness problems and deficits in attentional functions (ADHD) (e.g., Barkley, 1997a; Noreika et al., 2013). Currently, the CTAQ is only available in Dutch. For future research, using a translation of the CTAQ in English would create the opportunity to investigate psychometric properties of the CTAQ in other samples as well. Also, this would make the CTAQ available for more professionals and for scientific research.

Finally, in our sample of children aged 4–8 years, we found a sufficient internal consistency (as an indication for reliability) for the CTAQ total score and the CTAQ time estimation subscale. For the subscale time words, we found that internal consistency is insufficient. Future studies need to investigate why the latter is the case and how we can improve the reliability of this subscale.

Limitations of the current study

One limitation is that we did not conduct *a-priori* power analyses. Yet, we used the programming language of Quick R to compute the minimum number of participants needed.

This showed us, that in order to investigate whether a medium correlation (i.e., according to Cohen, $r = 0.30$) exists, with an effect size of 0.80, a minimum of 82 participants should have been included and in order to investigate whether a correlation of 0.70 exists (large, as we expected), with a power of 0.80, a minimum of 13 participants should have been included. This implies that our sample size ($n = 135$) is sufficiently large.

Another limitation of the current study is the heterogeneity of the group of non-typically developing children. Children were included in this group, based on parental reports. Only 10 (35.7%) of these children were classified with a developmental disorder by a professional, according to these parents. This percentage is not unexpected, given the (young) age of the children in our sample: in the Netherlands, psychological or behavioral developmental problems in children under the age of seven are only rarely classified. Nonetheless, follow-up research on the CTAQ can benefit from administering e.g., standardized parent-reports, such as Child Behavior Checklist (Achenbach, 1991) or Strengths and Difficulties Questionnaire (Goodman, 1997), to obtain more information about the developmental problems (such as the types of symptoms and symptom severity). Another option is, to specifically include children with, for example, ADHD or ASD by working together with mental health care institutions that provide diagnostics and treatment for these children. We recommend that for future research, *a-priori* power analyses are conducted to further investigate the clinical significance of the instrument and the underlying factor structure. Additionally, computing norms for the CTAQ total scale and its subscales would constitute an interesting and highly relevant next step. Also, most children in our sample have highly educated caregivers. For future research, it is interesting to administer the CTAQ to a sample which reflects the academic level and diversity in socioeconomic status of caregivers more evenly. We focused on studying validity of CTAQ, other psychometric properties such as the test-retest reliability were not tested in the present study. It is important to investigate other psychometric properties of CTAQ in future research. Our study can be considered as a pilot: it is the first time that psychometric properties, in this case the validity, of a child questionnaire on time awareness, i.e., the CTAQ, were studied in young children.

Clinical implications

In sum, this is the first study to describe the validity of the CTAQ, a performance task measuring time awareness in young children aged 4–8 years. Assessment of time awareness in this age period is believed to be important and may contribute to the understanding of (some) behavioral and developmental difficulties experienced by children with e.g., ADHD, since previous studies have reported time awareness problems in (at least some of) these children (Keulers & Hurks, 2021). A division in the CTAQ subscales may also be of clinical importance because it helps both professionals, caregivers, and children to investigate possible strengths and difficulties in children's time awareness. For that matter: our study indicates that the CTAQ has some potential to measure time awareness. Yet, as mentioned above, to fully cover the complex concept time awareness, the factor structure merits further research. To further enhance the clinical usability of the CTAQ subscales, adequate, age-related norms should be constructed so children can be compared to their peers in their development of time awareness.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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Data availability statement

All data, analyses code, and research materials are available by emailing the corresponding author and via Open Science Framework (OSF).

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