



# Time perception and Autistic Spectrum Condition: A Systematic Review.

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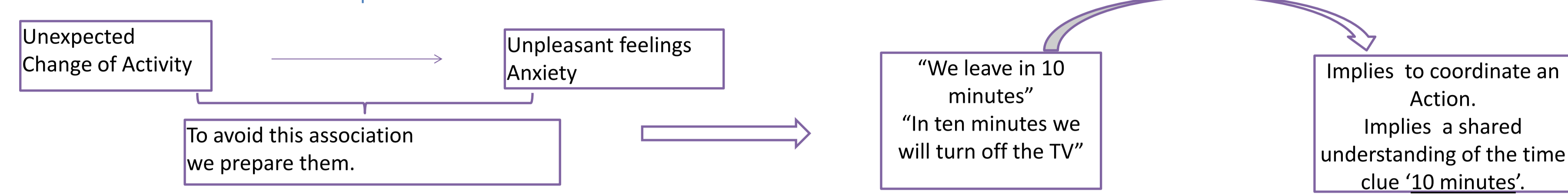
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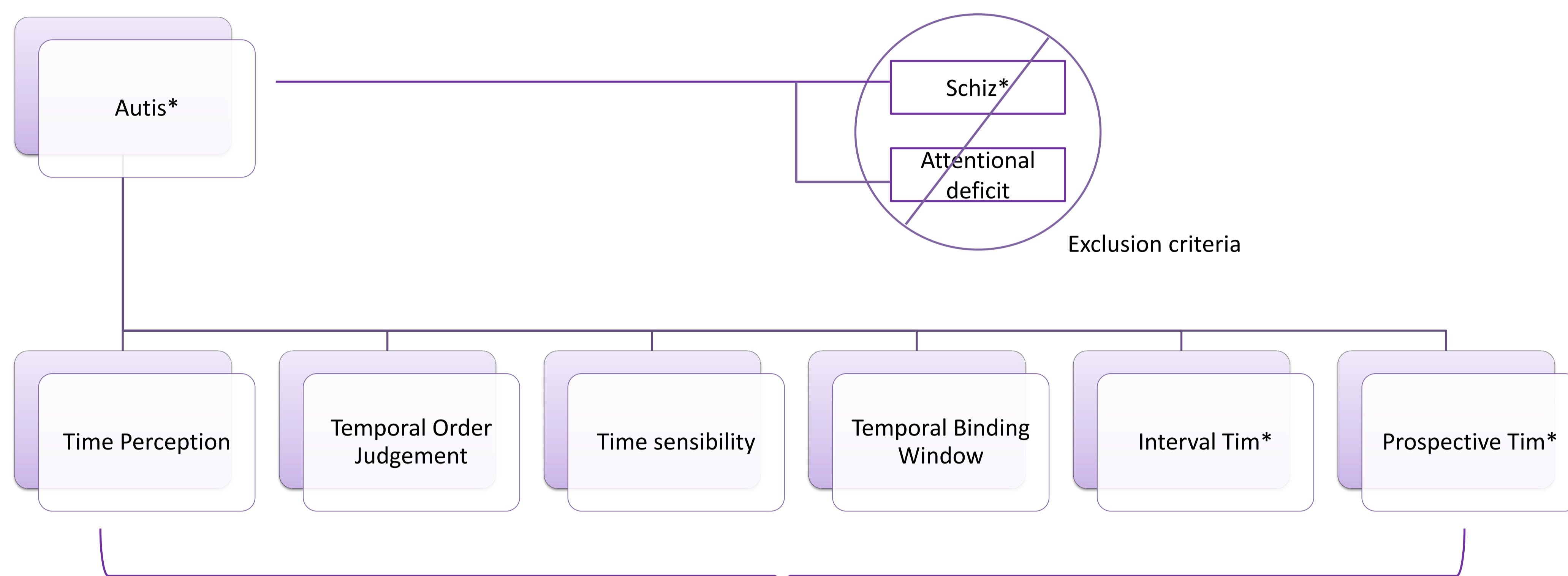
## INTRODUCTION

- Professionals and caregivers have reported that autistic people have problems with timing and time perception.
- We still do not know what type of time ability is different in ASC, or how possible issues in time perception are related with the social and non-social atypicalities in ASC.
- We often use time concepts when preparing ASC people for an oncoming change of activity.

Where does the question come from?



## METHODS



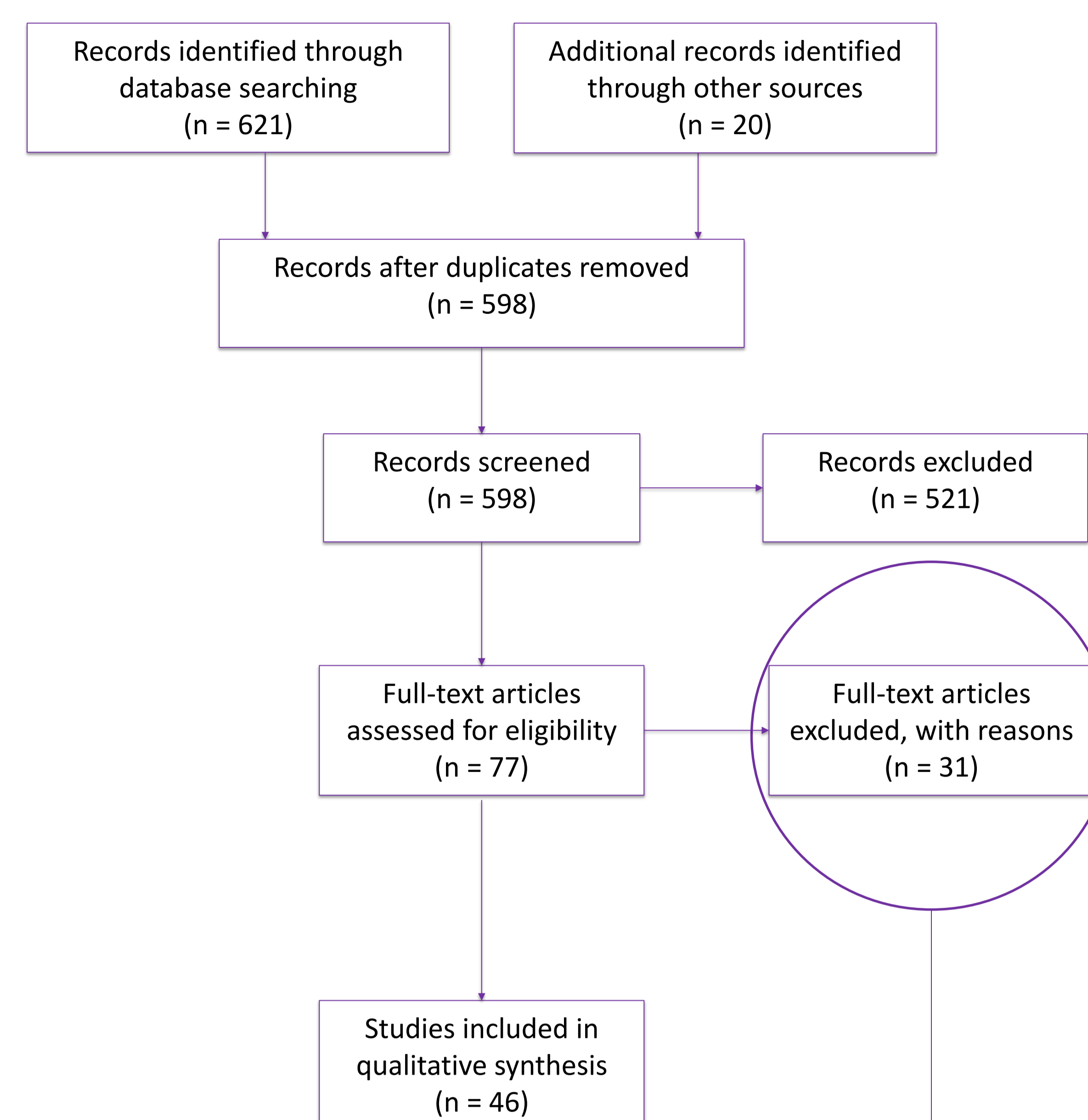
Systematic search in five databases:  
Web of Science (WOS), PubMed, Scopus, Wiley Online Library (WOL), and PsycINFO

Identification

Screening

Eligibility

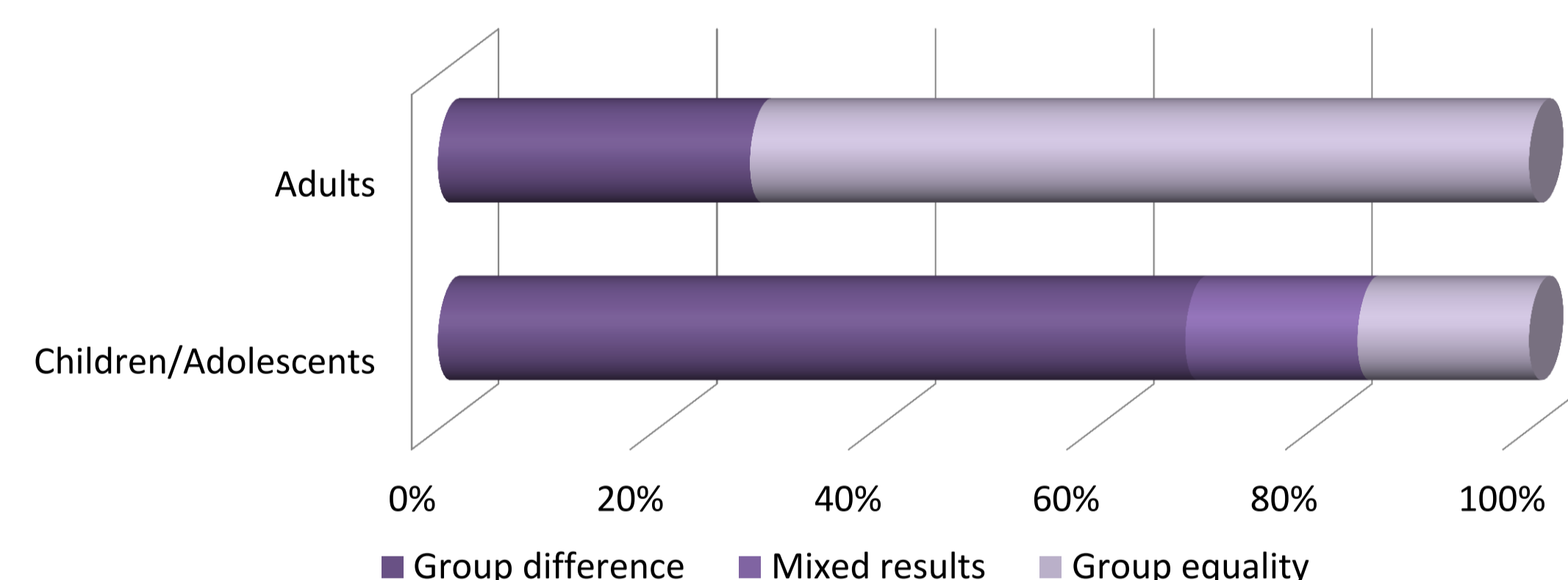
Included



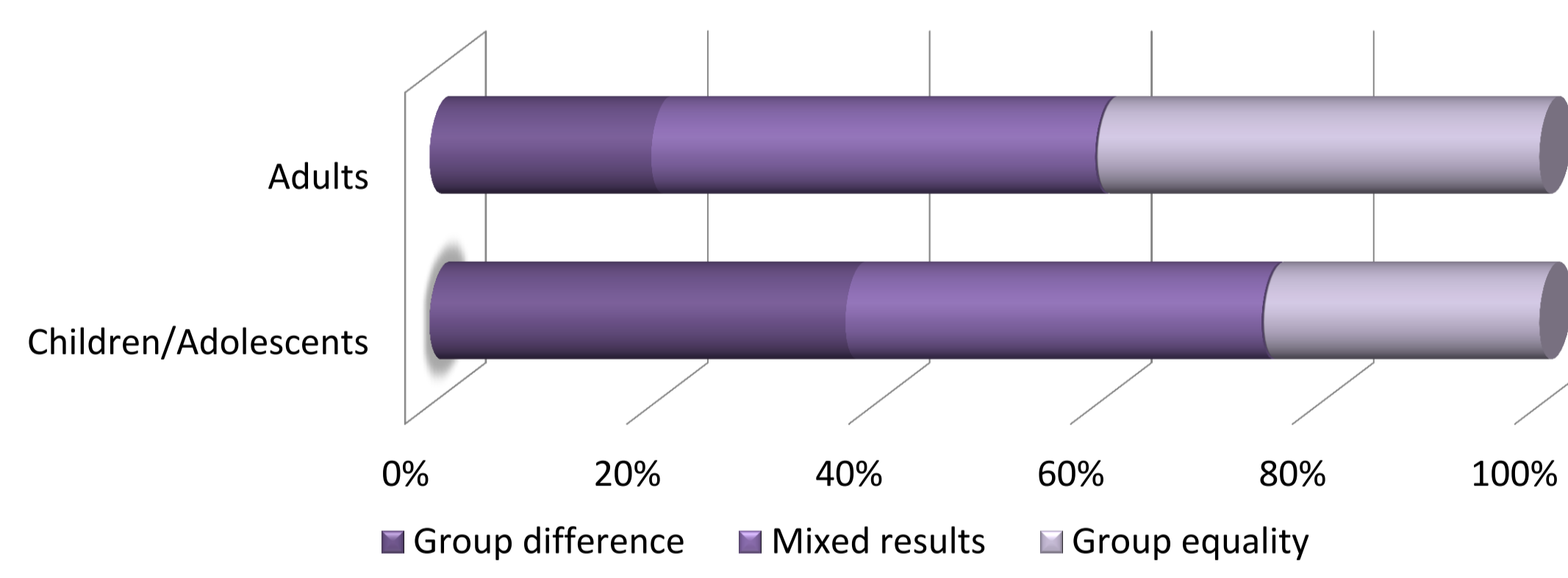
- 20: No time perception research, but other cognitive processes
- 5: No autism sample or the autism data were mixed with other conditions
- 2: Covered an area of research was not targeted in the current review: circadian timing
- 4 Not research articles, but theoretical

## RESULTS

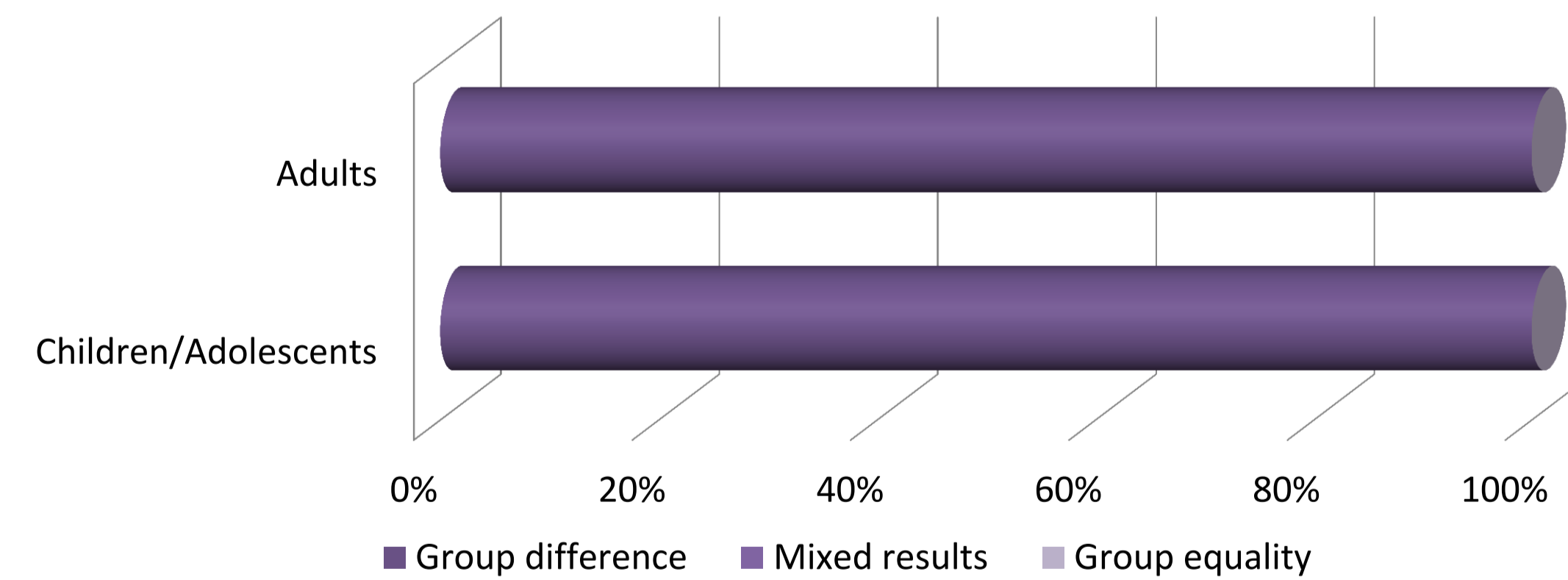
26 Time Sensitivity	7 temporal thresholds
	15 Temporal Order Judgements and multisensory temporal integration
	4 Electro-encephalography
14 Interval Timing	5 Prospective time by Comparison methods
	8 Prospective time by estimation methods
	1 Retrospective timing
8 High-order time processing	5 Time-based prospective memory
	1 Temporal Planning
	1 Memory for temporal order
	1 Diachronic Thinking



Wide variety of thresholds methods, and some sensory modalities are under-studied. There is a trend for less temporal acuity and multisensory temporal integration for socially relevant stimuli in ASC.

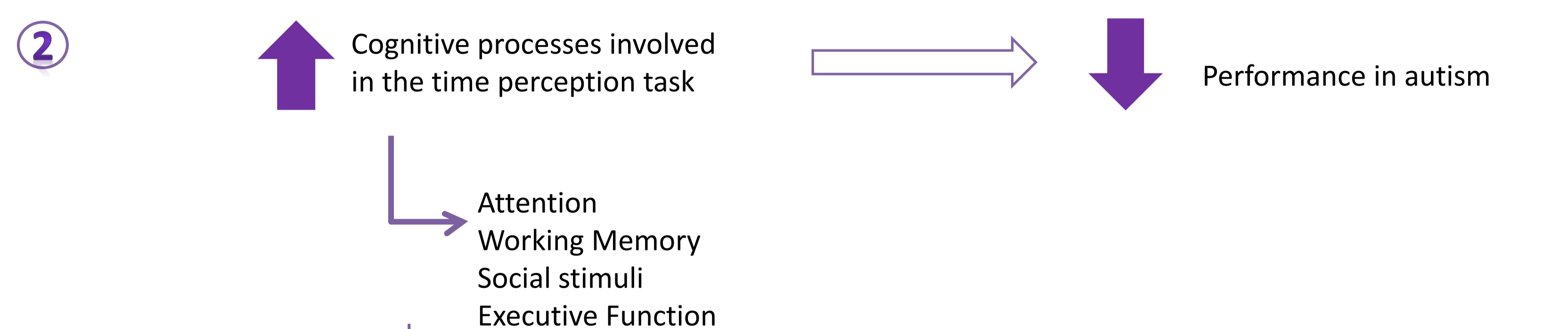
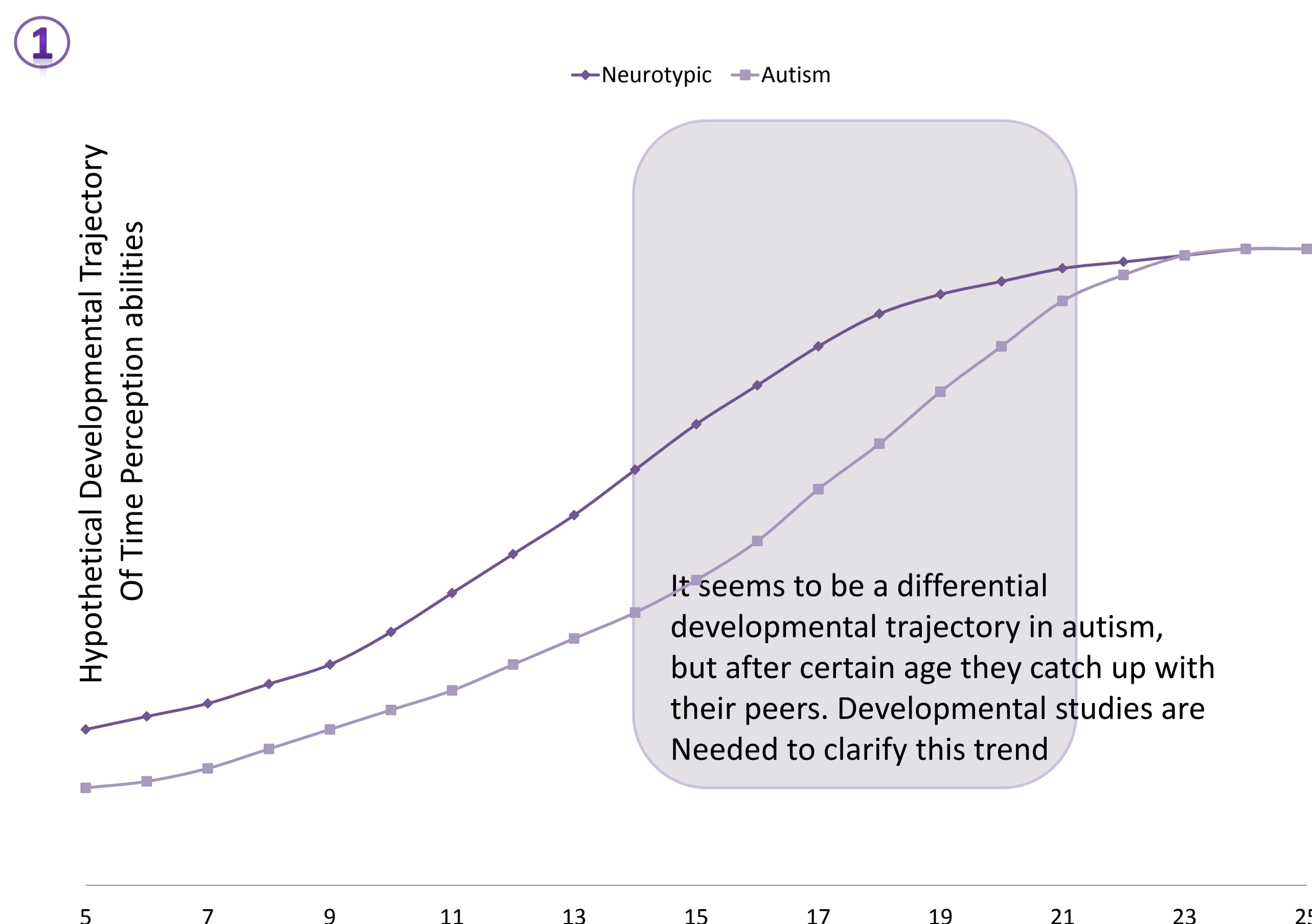


Trend towards lower accuracy in autism, but comparable consistency. Poorer performance reported in ASC is more likely to be anchored in working memory rather than pacemaker component of SET. No studies using both comparison and estimation methods.



Strong trend toward atypicalities in time-based prospective memory rather than event-based prospective memory. Full consistency of results showing impaired time perception abilities in autism in high-order time processing.

## CONCLUSION



It can be hypothesise Poorer performance in ASC is likely to be anchored in the integration of temporal information with the information from other cognitive processes.

- Some areas have been researched only once: Temporal planning, Memory for temporal order, Diachronic Thinking
- There are no published studies in:
  - retrospective timing and passage of time judgements in ASC
  - temporal processing and information processing rates in ASC
  - using measurements of the three different levels of time perception abilities in the same sample.

## Full list of publications included in the systematic review

Study	Sample	Task
Bhatara, A., Babikian, T., Laugeson, E., Tachdjian, R., Sininger, Y. S. (2013). Impaired timing and frequency discrimination in high-functioning autism spectrum disorders. <i>J Autism Dev Disord</i> 43(10): 2312-2328.	children/adolescents	Temporal thresholds
Jones CRG, Happé F, Baird G, Simonoff E, Marsden AJS, Tregay J, Phillips RJ, Goswami U, Thomson JM, Charman T (2009a) Auditory discrimination and auditory sensory behaviours in autism spectrum disorders, <i>Neuropsychologia</i> , Volume 47, Issue 13, November 2009, Pages 2850-2858, ISSN 0028-3932	children/adolescents	Temporal thresholds
Kargas, N., et al. (2015). "The Relationship Between Auditory Processing and Restricted, Repetitive Behaviors in Adults with Autism Spectrum Disorders." <i>Journal of Autism and Developmental Disorders</i> 45(3): 658-668.	Adults	Temporal thresholds
Mostofsky, S. H., Goldberg, M. C., Landa, R. J., & Denckla, M. B. (2000). Evidence for a deficit in procedural learning in children and adolescents with autism: implications for cerebellar contribution. <i>Journal of the International Neuropsychological Society</i> , 6(07), 752-759.	children/adolescents	Temporal thresholds
Poole, D., Gowen, E., Warren, P. a, & Poliakoff, E. (2015a). Investigating Visual-Tactile Interactions over Time and Space in Adults with Autism. <i>Journal of Autism and Developmental Disorders</i> . doi:10.1007/s10803-015-2492-8	Adults	Temporal thresholds
De Boer-Schellekens, L., Eussen, M., & Vroomen, J. (2013a). Diminished sensitivity of audiovisual temporal order in autism spectrum disorder. <i>Frontiers in Integrative Neuroscience</i> , 7, 8. doi:10.3389/fnint.2013.00008	children/adolescents	TOJ, Temp. Integration
Bebko, J.M., Weis, J.A., Demark, J.L. & Gomez, P. (2006). Discrimination of temporal synchrony in intermodal events by children with autism and children with developmental disabilities without autism. <i>Journal of Child Psychology</i> , 47, 88-98.	children/adolescents	TOJ, Temp. Integration
De Boer-Schellekens, L., Keetels, M., Eussen, M., & Vroomen, J. (2013b). No evidence for impaired multisensory integration of low-level audiovisual stimuli in adolescents and young adults with autism spectrum disorders. <i>Neuropsychologia</i> , 51(14), 3004–3013. doi:10.1016/j.neuropsychologia.2013.10.005	children/adolescents	TOJ, Temp. Integration
Falter, C. M., Elliott, M. a, & Bailey, A. J. (2012a). Enhanced visual temporal resolution in autism spectrum disorders. <i>PloS one</i> , 7(3), e32774. doi:10.1371/journal.pone.0032774	Adults	TOJ, Temp. Integration
Foss-Feig, J. H., Kwakye, L. D., Cascio, C. J., Burnette, C. P., Kadivar, H., Stone, W. L., & Wallace, M. T. (2010). An extended multisensory temporal binding window in autism spectrum disorders. <i>Experimental Brain Research</i> , 203(2), 381–389. doi:10.1007/s00221-010-2240-4	children/adolescents	TOJ, Temp. Integration
Greenfield, K., et al. (2015). "Visuo-tactile integration in autism: atypical temporal binding may underlie greater reliance on proprioceptive information." <i>Mol Autism</i> 6.	children/adolescents	TOJ, Temp. Integration
Grossman, R. B., et al. (2015). "'Look who's talking!' Gaze Patterns for Implicit and Explicit Audio-Visual Speech Synchrony Detection in Children With High-Functioning Autism." <i>Autism Research</i> 8(3): 307-316.	children/adolescents	TOJ, Temp. Integration
Irwin, J. R., Tornatore, L. A., Brancazio L., Whalen D. H. (2011). "Can Children With Autism Spectrum Disorders "Hear" a Speaking Face?" <i>Child Development</i> 82(5): 1397-1403	children/adolescents	TOJ, Temp. Integration
Kwakye, L. D., Foss-Feig, J. H., Cascio, C. J., Stone, W. L., & Wallace, M. T. (2011). Altered auditory and multisensory temporal processing in autism spectrum disorders. <i>Frontiers in Integrative Neuroscience</i> , 4, 1–11. doi:10.3389/fnint.2010.00129	children/adolescents	TOJ, Temp. Integration
Noel, J.-P., De Niar, M. A., Stevenson, R., Alais, D. and Wallace, M. T. (2016). Atypical rapid audio-visual temporal recalibration in autism spectrum disorders. <i>Autism Research</i> . doi:10.1002/aur.1633	children/adolescents	TOJ, Temp. Integration
Poole, D., Gowen, E., Warren, P.A., Poliakoff E. (2016) Brief Report: Which Came First? Exploring Crossmodal Temporal Order Judgements and Their Relationship with Sensory Reactivity in Autism and Neurotypicals <i>J Autism Dev Disord</i> (2016). doi:10.1007/s10803-016-2925-z	Adults	TOJ, Temp. Integration
Puts, N. A., Wodka, E. L., Tommerdahl, M., Mostofsky, S. H., & Edden, R. A. (2014). Impaired tactile processing in children with Autism Spectrum Disorder. <i>Journal of Neurophysiology</i> , 1803–1811. doi:10.1152/jn.00890.2013	children/adolescents	TOJ, Temp. Integration
Stevenson, R. A., Siemann, J. K., Schneider, B. C., Eberly, H. E., Woynaroski, T. G., Camarata, S. M., & Wallace, M. T. (2014). Multisensory temporal integration in autism spectrum disorders. <i>The Journal of Neuroscience</i> , 34(3), 691–697. doi:10.1523/JNEUROSCI.3615-13.2014	children/adolescents	TOJ, Temp. Integration
Tommerdahl, M., Tannan, V., Holden, J. K., & Baranek, G. T. (2008). Absence of stimulus-driven synchronization effects on sensory perception in autism: Evidence for local underconnectivity? <i>Behavioral and Brain Functions</i> , 4, 19. doi:10.1186/1744-9081-4-19	Adults	TOJ, Temp. Integration
Wada, M., Suzuki, M., Takaki, A., Miyao, M., Spence, C., & Kansaku, K. (2014). Spatio-temporal processing of tactile stimuli in autistic children. <i>Scientific Reports</i> , 4, 5985. doi:10.1038/srep05985	children/adolescents	TOJ, Temp. Integration
Lepistö T., Silokallio S., Nieminen-von Wendt T., Alku P., Näätänen R., Kujala T. (2006) Auditory perception and attention as reflected by the brain event-related potentials in children with Asperger syndrome, <i>Clinical Neurophysiology</i> , Volume 117, Issue 10, October 2006, Pages 2161-2171, ISSN 1388-2457, http://doi.org/10.1016/j.clinph.2006.06.709	children/adolescents	EEG
Kujala, T. Aho, E., Lepistö, T., Jansson-Verkasalo, E., Nieminen-von Wendt, T., von Wendt, L. Naatanen, R. (2007). "Atypical pattern of discriminating sound features in adults with Asperger syndrome as reflected by the mismatch negativity." <i>Biol Psychol</i> 75(1): 109-114.	Adults	EEG
Lepistö T, Kujala T, Vanhala R, Paavo A, Huottilainen M, Naatanen R (2005) The discrimination of and orienting to speech and non-speech sounds in children with autism. <i>Brain Research</i> 1066 (2005) 147 – 157 DOI: 10.1016/j.brainres.2005.10.052	children/adolescents	EEG
Lepistö Tuulia, Nieminen-von Wendt Taina, von Wendt Lennart, Näätänen Risto, Kujala Teija (2007) Auditory cortical change detection in adults with Asperger syndrome, <i>Neuroscience Letters</i> , Volume 414, Issue 2, 6 March 2007, Pages 136-140, ISSN 0304-3940, http://doi.org/10.1016/j.neulet.2006.12.009.	Adults	EEG
Allman, M., DeLeon, I.G & Wearden, J.H. (2011). Psychophysical assessment of timing in individuals with autism. <i>American Journal on Intellectual and Developmental Disabilities</i> , 116, 165-178.	children/adolescents	Prosp. Time: Comparison Methods
Brodeur, D. A., et al. (2014). "Time Estimation Among Low-Functioning Individuals With Autism Spectrum Disorders: Evidence of Poor Sensitivity to Variability of Short Durations." <i>Autism Research</i> 7(2): 237-244.	children/adolescents	Prosp. Time: Comparison Methods
Falter, C. M., Noreika, V., Wearden, J. H. Bailey A. J. (2012). "More consistent, yet less sensitive: Interval timing in autism spectrum disorders." <i>The Quarterly Journal of Experimental Psychology</i> 65(11): 2093-2107.	Adults	Prosp. Time: Comparison Methods
Gil S, Chambres P, Hyvert C, Farget M, Droit-Volet S (2012) Children with Autism Spectrum Disorders have "The Working Raw Material" for Time Perception. <i>Plos One</i> 7(11).	children/adolescents	Prosp. Time: Comparison Methods
Jones, C. R. G., Lambrechts A., Gaigg S. (2017). "Using Time Perception to Explore Implicit Sensitivity to Emotional Stimuli in Autism Spectrum Disorder." <i>Journal of Autism and Developmental Disorders</i> : 1-13.	Adults	Prosp. Time: Comparison Methods
Brenner, L. A., Shih, V. H., Colich, N. L., Sugar, C. A., Bearden, C. E. and Dapretto, M. (2015), Time Reproduction Performance Is Associated With Age and Working Memory in High-Functioning Youth With Autism Spectrum Disorder. <i>Autism Res</i> , 8: 29–37. doi:10.1002/aur.1401	children/adolescents	Prosp. Time: Estimation Methods
Gowen, E., & Miall, R. C. (2005). Behavioural aspects of cerebellar function in adults with Asperger syndrome. <i>The Cerebellum</i> , 4(4), 279-289.	Adults	Prosp. Time: Estimation Methods
Karaminis T, Cicchini G, Neil L, Cappagli G, Aagten-Murphy D, Burr D and Pellicano E (2016). Central tendency effects in time interval reproduction in autism. <i>Sci. Rep.</i> 6, 28570; doi: 10.1038/srep28570	children/adolescents	Prosp. Time: Estimation Methods
Maister L, Plaisted-Grant KC (2011) Time perception and its relationship to memory in autism spectrum conditions. <i>Dev Sci.</i> 2011; 14(6):1311–1322. [PubMed: 22010891]	children/adolescents	Prosp. Time: Estimation Methods
Martin, J. S., Poirier, M., & Bowler, D. M. (2010). Brief report: Impaired temporal reproduction performance in adults with autism spectrum disorder. <i>Journal of autism and developmental disorders</i> , 40(5), 640-646.	Adults	Prosp. Time: Estimation Methods
Sperduti, M., Pieron, M., Leboyer, M., Zalla, T. (2014). "Altered Pre-reflective Sense of Agency in Autism Spectrum Disorders as Revealed by Reduced Intentional Binding." <i>Journal of Autism and Developmental Disorders</i> 44(2): 343-352.	Adults	Prosp. Time: Estimation Methods
Szelag E, Kowalska J, Galkowski T, Poppel E. Temporal processing deficits in high-functioning children with autism. <i>Br J Psychol.</i> 2004; 95(Pt 3):269–282. [PubMed: 15296535]	children/adolescents	Prosp. Time: Estimation Methods
Wallace GL, Happe F. (2008) Time perception in autism spectrum disorders. <i>Research in Autism Spectrum Disorders</i> . 2008; 2:447–455	children/adolescents	Prosp. Time: Estimation Methods
Poole et al. (unpublished pilot data)	Adults	Retrospective time
Williams, D., Boucher, J., Lind, S., Christopher J. (2013). "Time-based and event-based prospective memory in autism spectrum disorder: The roles of executive function and theory of mind, and time-estimation." <i>Journal of Autism and Developmental Disorders</i> 43(7): 1555-1567.	children/adolescents	Time-based prosp. Memory
Altgassen, M., Koban, N., Kliegel, M.I. (2012). "Do adults with autism spectrum disorders compensate in naturalistic prospective memory tasks?" <i>J Autism Dev Disord</i> 42(10): 2141-2151.	Adults	Time-based prosp. Memory
Bennetto, L., Pennington, B.F. & Rogers, S.J. (1996). Intact and impaired memory functions in autism. <i>Child Development</i> , 67, 1816-1835.	children/adolescents	Memory for temporal Order
Boucher, J., Pons, F., Lind, S., & Williams, D. (2007). Temporal cognition in children with Autistic Spectrum Disorder: Tests of diachronic thinking. <i>The Journal of Autism and Developmental Disorders</i> , 37, 1412-1429.	children/adolescents	Diachronic Thinking
Henry, J. D., et al. (2014). "A Virtual Week study of prospective memory function in autism spectrum disorders." <i>J Exp Child Psychol</i> 127: 110-125.	children/adolescents	Time-based prosp. Memory
Kretschmer, A., et al. (2014). "Prospective memory in adults with high-functioning autism spectrum disorders: exploring effects of implementation intentions and retrospective memory load." <i>Res Dev Disabil</i> 35(11): 3108-3118.	Adults	Time-based prosp. Memory
Williams, D. M., Jarrold, C., Grainger, C., Lind, S. E. (2014). "Diminished time-based, but undiminished event-based, prospective memory among intellectually high-functioning adults with autism spectrum disorder: relation to working memory ability." <i>Neuropsychology</i> 28(1): 30-42	Adults	Time-based prosp. Memory