2020

Retrieval-Induced Forgetting in Autism Spectrum: Combining Narrative Experience with Clinical Research to Explore Stress-Induced, Transitory Retrograde Amnesia

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RETRIEVAL-INDUCED FORGETTING IN AUTISM SPECTRUM: COMBINING NARRATIVE EXPERIENCE WITH CLINICAL RESEARCH TO EXPLORE STRESS-INDUCED, TRANSITORY RETROGRADE AMNESIA

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SUBMITTED TO SCRIPPS COLLEGE AND POMONA COLLEGE IN PARTIAL FULFILLMENT OF THE BACHELOR OF ARTS DEGREE

MAY 11, 2020

Abstract

Currently, psychological research explores autism, a blanket term for a range of neurobiological and developmental differences, through a clinical, as opposed to an experiential, lens. Autism has only existed as formal diagnosis under that name since 1943 (Kanner); however, the advocacy of activists such as Temple Grandin, a slaughterhouse systems designer best known for documenting her life with autism in a series of autobiographic accounts, has begun to legitimize the incorporation of emic experiences of autism within clinical research. Researcher Dermot Bowler and colleagues (2011) have conducted extensive reviews of memory distinctions in autism, finding differences of varying degrees across variety of memory types. However, the retrieval-induced forgetting mechanism, first demonstrated by Michael Anderson et al. in 1994, wherein remembering can cause forgetting of unpracticed semantically related stimuli, has not been explored in autistic populations. Additionally, individuals with autism have, outside published literature, reported experiencing a temporary amnesia for the day's events after experiencing stress; something also not explored by Bowler or other researchers. This pilot study seeks to understand 1) whether individuals with autism show retrieval-induced forgetting and 2) whether temporary forgetting post-stress is specific to autism, and, if so, what characteristics make it distinct. The results indicate that individuals with autism do exhibit retrieval-induced forgetting and that differences in relational memory processing, specifically, item dependent versus semantic, are associated with this temporary forgetting effect. Future research should investigate whether retrieval-induced forgetting exists in autism under stress and conduct a variety of different qualitative surveys on the autistic experience of temporary forgetting.

Acknowledgements

I would like to thank my Pomona College thesis advisor, Laura Johnson, for her academic and emotional support and for her creativity in adapting this thesis during the pandemic while maintaining its experimental integrity. Next, I would like to thank my Scripps College thesis advisor, Michael Spezio, for his detailed feedback, thoughtful critiques, and for his dedication to illustrating developmental differences as strengths, not weaknesses. Furthermore, I would like to thank Lise Abrams and Deborah Burke for their joint support and guidance over the last four years.

I cannot begin to express my gratitude for my professional mentors, Rosemary White, Jeannette Wake, and Kris Johnson for their guidance, patience, and continual reminder to see the world through another's eyes.

To my friends, teammates, and classmates: thank you for listening to my ideas, for giving me food or encouraging me to get some sleep, and for being my home away from home.

Finally, to my family (Mum, Dad, Nannie, Grampie, and Willow): thank you for raising me to do the right thing, in my thesis, in my schoolwork, and most importantly, in my choices.

I would like to dedicate this thesis to the children and families I have had the privilege of working with over the last four years. You inspire me every day.

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Retrieval-Induced Forgetting in Autism Spectrum: Combining Narrative Experience with Clinical Research to Explore Stress-Induced, Transitory Retrograde Amnesia

Henry Molaison (*i.e.* HM). *Blade Runner*. *Inception*. Stories about memory, about the human capacity for maintaining a temporal identity, have fascinated both public and scientific audiences for millennia. While a range of memory phenomena have been documented and studied, largely from laboratory perspectives, memory in certain clinical populations, specifically, those individuals who identify with developmental differences, is underrepresented in the literature. For instance, individuals with autism have long reported first-person accounts of both enhanced and diminished memory domains (Grandin 2008). Most of these have been examined in a laboratory setting rather than being compared to the actual narrative experience of those who describe them (Badone et al. 2016). Thus, clinical research to date is more concerned with etic (from an outside perspective) observations, as opposed to emic (first-person experience) perspectives. Moreover, individuals with autism may experience a temporary retrograde amnesia for the day's events after experiencing intense, but not traumatic, stress – a phenomenon which, according to first-hand accounts of individuals I have directly spoken with, resolves itself within a 24-hour period. This transitory effect is superficially like the retrieval-induced forgetting phenomenon first described by Michael Anderson, wherein competition from semantically related stimuli causes brief amnesia for memories or items from the same category as the target (Anderson et al. 1994).

This study has two purposes: 1) to determine whether individuals with autism display retrieval-induced forgetting effects more similar to neurotypical groups or more similar to clinical populations with high state anxiety or posttraumatic stress, and 2) to interpret the laboratory findings with help from the first-person narratives given by individuals with autism

that describe their lived experience of stress-induced, transitory retrograde-amnesia for the day's events. It is helpful to obtain an epistemological and historical understanding of autism, as both a diagnosis and a human experience, before examining the intersection between autism, memory, and forgetting.

History of Autism

Across pop culture, the word autism conjures images of Dustin Hoffman's iconic *Rain Man* performance and, most recently, the inclusion of a Sesame Street character with autism. The journey from *Rain Man*, a stand-alone film made for adults, to the representation of autism in mainstream children's television, illustrates the degree to which public knowledge and acceptance of these diagnostic spectra have evolved since Leo Kanner's seminal description of the syndrome in 1943 as "Autistic Disturbances of Affective Contact" (Kanner 1943). However, as social acceptance and knowledge of autism increase, a clinical debate over how to define autism, diagnostically, genetically, and ontologically, has raged beneath the surface. For the purposes of this study, it is necessary that we understand the history of autism, as a diagnosis, as an identity, and as a first-person experience of the world.

First clinically described in 1943 by child psychiatrist Leo Kanner, autism has existed far longer than its relatively recent induction into psychopathology would suggest. The Diagnostic and Statistical Manual, Fifth Edition (DSM-V) currently defines autism as a social communication syndrome with a tendency towards repetitive behaviors and narrowed interests (American Psychiatric Association, 2013). Diagnostic and epistemological descriptions of autism remain under scrutiny, with each new iteration of definitions emphasizing a variety of key features. Using case studies of 11 prepubescent children, including family psychosocial histories and detailed behavioral observation, Leo Kanner identified several characteristics of autism

inexplicable by other diagnoses in 1943. These included but were not limited to: decreased social interaction with peers, delayed motor development or postural challenges, echolalic speech with limited generative abilities, early or delayed language development, misuse of personal pronouns, enhanced rote memorization abilities, challenges in comprehension of symbolic language – "literalness" – preservation of sameness in the environment, and hyperarousal for certain sensory stimuli. In arguing for autism as a specific diagnosis, Kanner remarked on the absence of a social connection within seemingly normal intelligence (1943). Despite continual revision of the DSM and further diagnostic criteria, all of Kanner's proposed symptoms are or have been alluded to across historic descriptions of autism.

Most notably, the DSM-V only requires two categories of impacted functioning for an autism diagnosis: challenges in social communication and interaction, for which three subcategories of possible symptoms are enumerated, and restricted interests and repetitive behaviors, for which at least two symptoms from the DSM-V's provided list must be present (American Psychiatric Association, 2013). Thus, of Kanner's originally observed traits of autism, current diagnostic standards do not require challenges related to language ability, sensory integration, or memory, although such difficulties may still be present.

Leo Kanner's historical representation of autism was echoed by Austrian psychiatrist Hans Asperger in 1944. Asperger noted that individuals he diagnosed with autism had difficulties with social interaction, restricted interests, advanced rote memory, language development challenges, sensory integration difficulties, and, although not specifically stated by Kanner, heritability within the family (Asperger & Frith, 1944). As with Kanner's original list, not all Asperger's clinical observations are still included in the DSM-V; however, his emphasis on the familial component of the autism diagnosis remains one of the more hotly contested

debates surrounding the neurobiological origins of autism. Current literature boasts a tempestuous argument surrounding the role of environment versus genetics in the development of autism – a diagnostic nature versus nurture debate that continues to shift with each year (see Strathearn 2009 for a comprehensive list of proponents for each side).

Genetics of Autism

While most information regarding the heritability of autism is found in twin studies, two population-based cohorts conducted in Sweden and England, respectively, yield a more nuanced presentation of autism's genetic components. In 2014, analysis of children born between 1982 and 2006 in Sweden reveals that, in those children who went on to develop autism, the heritability rate was about 50%, compared to much higher estimates found previously in the literature (Sandin et al.). Additionally, non-shared environmental influences exert minimal effects, while individuals with siblings with autism who have 50% of their genes in common are ten times more likely to develop autism (Sandin et al. 2014). This latter finding implies further nuances regarding the role of specific genetic variants within families, which has yet to be determined in research. Although not mentioned by Sandin et al. (2014), the role of cultural differences in the definition of autism also affects these data. In 2015, analysis of children born in the UK identifies genetic influences as the primary indicator of a diagnosis of autism, followed by non-shared environmental influences (Colvert et al.). Unlike other studies, Colvert et al.'s (2015) UK-based population-cohort also includes individuals with subclinical symptoms of autism, lending statistical credence to the existence of what they term "a broader autism phenotype" (421). Beyond autism heritability, a meta-analysis of oxytocin receptor (OXTR) studies indicates a relationship between the OXTR and autism, specifically, regarding functionality in socio-affective situations (LoParo & Waldman 2015). Unlike studies of twins,

these oxytocin receptor findings raise questions about the role of neurotransmitters in autism, specifically, those involved in emotional processing or social communication and interaction.

First Person Accounts of Autism

While Kanner and Asperger were correct in emphasizing the genetic component of autism, recent advocacy work by individuals with a diagnosis of autism illustrates the importance of incorporating first-person narratives, which have historically been ignored, into clinical research. Animal rights activist, autism advocate, and author Temple Grandin describes her first-person experience of the diagnosis in the autobiographical *Thinking in Pictures: My Life with Autism*. She details her transition from early childhood as a non-verbal, emotionally frustrated four-year-old, to a world-renowned author and humane-slaughterhouse designer. Throughout the book, Grandin paints a vivid picture of her own internal thought processes, providing fascinating insights regarding the quotidian emotional and sensory experiences of those with autism. Grandin (2008) describes how "like a prey-species animal, many people with autism experience fear as the primary emotion," and writes of her surprise at realizing that so-called neurotypical folks do not experience this physiological unrest as their own daily reality (199). In this case, Grandin's use of the phrase "primary emotion" indicates an ontological reality only hinted at within autism literature, yet overwhelmingly absent from qualitative research. While Grandin does not comment on the neural, biological, or psychological underpinnings of that experience, her first-person report provides a primary account of physiological and emotional components of the autism experience that clinical research lacks.

Grandin asserts that fear is her most common emotional state. Author and autism advocate Liane Holliday Willey corroborates those descriptions with her own account of living with Asperger's Syndrome. Willey (2014) describes the physiological distress stimulated by

navigating her college campus, writing that "all these elements forced my sensory integration dysfunction into a high state of chaos. Without fail, I would arrive at the university sweating, sticky, anxious, dazed, and confused" (68). As in Grandin's account, Willey (2014) indicates that, for a person with autism – of which Asperger's is wholeheartedly a part – quotidian actions of even navigating space can produce sensations of fear and anxiety.

Additionally, Willey (2014) explicitly links this intense discomfort to her compounded sensory disintegration. Grandin (2008) also comments on this added layer when describing how autism interlinks with memory, writing "sensory based thinking is subconscious in most people. I think with the primary sensory based subconscious areas of the brain . . . Since I think with my subconscious, repression does not occur, and denial is impossible. My 'search engine' has access to the entire library of detailed sensory memories" (219). In accordance with Willey's description of tantrums induced by sensory overload, Grandin has intentionally combined the theoretical literature with her own ontological experience, creating 1) an argument for the inclusion of more first-person accounts in autism literature and 2) highlighting potential discrepancies between how individuals with autism and so-called neurotypical individuals interact with and access memories. Of particular interest is Grandin's emphasis on her "sensory based thinking," implying that, since the sensory modality is most active in her own experience, it is not illogical to assume, as Willey has done, that anxiety, physiological discomfort, and excessive fear response are due primarily to challenges in sensory integration and processing.

Anxiety, Sensory Overresponsivity, and Autism

Not only do Grandin's and Willey's separate accounts agree, the clinical literature confirms a statistically significant relationship between sensory challenges and anxiety in individuals with autism. In their seminal work, researchers Green and Ben-Sasson (2010)

propose two explanatory models for the relationship between autism, anxiety, and sensory over-responsivity. First is the Primary Anxiety model, which postulates that anxiety experienced by individuals with autism induces a state of physiological hyperarousal, which, in turn, causes the individual to be more alert to sensory elements of the environment. Second is the Primary SOR (sensory overresponsivity) Model, which posits that innate sensory dysfunction in individuals with autism causes an overly generalized fear response in reaction to overwhelming stimuli, thus creating a kind of learned anxiety overtime. These theoretical models highlight the ontological importance Grandin and Willey ascribe to their own experiences with autism, and, they do so using clinical perspectives testable in an experiment. In a study using parent reported SOR indices for children with autism, attention deficit and hyperactivity, and typical development, researchers Lane et al. note a direct effect of SOR on anxiety. This lends tentative support to the Primary SOR model proposed by Green and Ben-Sasson (2010) and provides initial clinical credence to Grandin's and Willey's first-person accounts. However, further investigation is necessary to more soundly establish the relationship between SOR and anxiety (Lane et al. 2012).

Neuroimaging also supports both the Primary SOR Model and Grandin's and Willey's perspectives, with researchers Green et al. (2016) indicating that excess activity in the amygdala and insula is found in individuals with autism when presented with uncomfortable auditory and tactile stimuli, compared to neurotypical controls. Green et al. (2016) also report that individuals with autism display longer habituation times for the stimuli than the neurotypical control group, implying that, not only is SOR a causal factor for anxiety in autism, but that sensory processing challenges are rooted in hypersensitivity in emotional processing areas coupled with decreased ability to adapt to said stimuli.

Memory and Autism

Beyond the fields of emotional processing and sensory differences, however, exceptional or unusual feats of memory have been both historically and clinically described in individuals with autism. Kanner identified these observable differences in memory experienced by those with autism and they have been explored in the literature in areas of episodic, spatial, temporal, working, short-term, autobiographical, and declarative memory, to name a few (Southwick et al. 2011, Maister and Plaisted-Grant 2011, Lind et al. 2014, Barendse et al. 2013, Bowler et al. 2011). Researchers Bowler et al. (2011) advocate for increased emphasis on memory processes in autism, asserting that such clinical research "can provide clues to underlying cognitive and neuro-psychological atypicalities as well as giving us a window onto their inner experiences of the world" (316). This illustrates, as Grandin and Willey so eloquently describe, the necessity of incorporating more first-person narratives into autism literature.

In their review of the literature for memory processes within autism, researchers Bowler et al. (2011) examine the experimental methods and tasks best suited to this population, as well as what specific domains of memory are elicited by each. For instance, Bowler et al.'s (2011) findings imply that short-term memory of individuals with autism is impaired only when the span task used has more cognitive load, and even then, results are not hugely statistically significant. Additionally, Bowler et al. (2011) report that free recall tasks pose the greatest challenge in memory performance for individuals with autism, likely due to a different categorization schema, while list learning occurs more slowly than in typically developing controls, also indicating an organizational difference specific to autism. Moreover, Bowler et al. (2011) write that individuals with autism have different galvanic skin response to emotional words than control groups, wherein the reaction to emotional and neutral words for individuals

with autism are more similar than for control group. Lastly, Bowler et al. (2011) indicate that the autobiographical memory of individuals with autism is significantly decreased compared to neurotypical controls. To this point, previous findings imply that short-term memory – upon which episodic and autobiographic memory rely – in autism exhibits differences in response to increased cognitive load and complexity (Barendse et al. 2011). Increases in both these areas result in a greater difference in performance, indicating that short-term memory in autism shows specific differences in relation to stimuli volume and integration of multiple stimuli or components. In other words, differences in short-term memory performance between individuals with autism and neurotypical controls are not observable unless the tasks involve high cognitive load, or the stimuli possess a certain level of complexity (Barendse et al. 2011). In a comparison of neuropsychological studies on working memory in autistic adolescents, Barendse et al. (2011) review maximum load working memory tasks. Within their analyses, individuals with autism show a diminished performance for Wide-Range Assessment of Memory and Learning tests (WRAML FW), as well as spatial working memory tests (CANTAB SWM), and oculomotor delayed response tasks (ODR) (Barendse et al. 2011). These results suggest that short-term memory impairments in autism are minimal within specific tests of working memory but significant across working memory as a whole (Barendse et al. 2011). Such parameters indicate that short-term memory differences for individuals with autism are apparent at the integration or encoding levels. This explains why social scenarios, in which the integration of multiple informational modalities is necessary, may present particular challenges (Bowler et al. 2011).

Of these memory functions studied within autism, one – temporal memory, or the perception and ontological experience of time – has been examined extensively. Researchers Maister and Plaisted-Grant (2011) report that individuals with autism experience significant

challenges in temporal reproduction for durations of less than 2 seconds, which are thought to be due to attentional processes, and for durations of greater than 45 seconds, likely indicative of episodic memory differences. Additionally, Maister and Plaisted-Grant (2011) reveal that individuals with autism, in the longer duration reproductions, likely do not participate in reorganization of their memories to the same extent as typically developing controls, suggesting a challenge in integrating both reproduction and organization tasks. While it is unclear which of the two processes mediates the other, challenges in combining the two, as opposed to their existence as separate abilities, implies decreasing temporal abilities.

Besides temporal reproduction, differences in abilities related to spatial working memory have also been observed. For instance, researchers Lind et al. (2014) report that individuals with autism exhibit reduced abilities for memory-guided spatial navigation, contributing to diminished performance on scene construction and mental simulation tasks. Moreover, Lind et al. (2014) indicate that episodic memory supports these spatial differences as measured by event descriptions, which involves processes of generalization and creating expectations or hypotheticals about the future. Furthermore, in a review of neuroimaging studies on autism and working memory, researchers Barendse et al. (2011) assert that spatial span, continual reorganization of information based on the situation, and processing of nuanced social interactions are impaired within autism. Most notably, individuals with autism did not display challenges with spatial span tasks unless the number of stimuli was increased to a certain threshold (Barendse et al. 2011), suggesting that working memory challenges in autism are related to cognitive load as opposed to isolated ability. Therefore, as determined by Barendse et al. (2011), “the complexity of the information to be processed, rather than the specific content of the information” is likely what mediates working memory differences in individuals with autism

(5). Further research indicates that structures and paradigms for social interaction are memorized via declarative memory, as opposed to being learned and becoming an ability requiring less effort (Barendse et al. 2011). This distinction is experientially described by Temple Grandin (2008) in her autobiography, wherein she asserts that "after many years I have learned – by rote – how to act in different situations. I can speed-search my CD-ROM memory of videotapes and make a decision quite quickly" (158-9). In this case, Grandin's use of the phrase "by rote" describes not only Barendse et al.'s (2011) and Kanner's (1943) initial findings, it emphasizes that individuals with autism can also quite succinctly describe their emic experience of these empirically-based cognitive findings. This overlap between first-person narratives and clinical research emphasizes the necessity of supplementing both elements with the other, by means of creating a more comprehensive understanding of autism as a state of being, to which research is a tool for gaining more insights.

In addition to establishing the range of detection for a variety of memory differences within autism, understanding which modalities are appropriate for testing those types of memory is imperative. For instance, researchers Southwick et al. (2011) indicate that differences in cognitive domains that influence IQ, such as verbal ability, means that using intelligence testing as a correlate for memory, especially for individuals with autism, fails to account for myriad other cognitive challenges or differences that may affect IQ. Additionally, Southwick et al. (2011) posit that episodic memory capacity in autism is diminished due to differences in how information is encoded and arranged. The researchers posit that lower retrieval scores for individuals with autism are accounted for by this model (Southwick et al. 2011) which corroborates Temple Grandin's description of a CD-ROM retrieval method while acknowledging that it is not recall, but encoding, that creates memory challenges.

Research on how emotion impacts memory on many levels is important beyond understanding how episodic and working memory function in autism, especially with regards to the encoding process. To this point, researchers Maras et al. (2012) determine that individuals with autism demonstrate increased memory for emotional stimuli to the same extent as neurotypical controls, but that the autism group had a diminished recall of all information, regardless of emotionality. However, Bowler et al. (2011) indicate that individuals with autism rely, to a greater extent than so-called neurotypical individuals, on item-dependent processing, which is the processing of items and stimuli in isolation from other related ones, as opposed to relational processing, or the connections, including semantics, between stimuli.

Retrieval-Induced Forgetting

One of the memory paradigms left entirely unexplored in the field of autism research, however, is Michael Anderson's seminal phenomenon of retrieval-induced forgetting. First discovered in their 1994 study, Anderson et al. define retrieval-induced forgetting as "repeated retrieval of a given item will strengthen that item, causing loss of retrieval access to other related items" (1063), specifically, for other items within that semantic category. In their seminal study, Anderson et al. (1994) reveal that, after presentation of several different semantic groups, and subsequent retrieval study of specific items in those groups, recall of target items diminishes retrieval abilities for unpracticed items from that same semantic category. For example, in a retrieval-induced forgetting task, an individual is presented with a list of fruits, for which half are practiced, and half are not. In a later recall task, given after a distractor, the participants are asked to remember target words using category-cued recall, wherein practiced items from the same category are inhibited after recall of the target. Thus, recall of "fruit: banana" inhibits recall of "fruit: orange," but not "animal: dog." In other words, by recalling one item, recall of

semantically related competitors is inhibited, while unrelated ones are unaffected. Additionally, this retrieval-induced forgetting effect persists for up to 20 minutes beyond the testing period, indicating that such inhibitory effects can have consequences for long term memory as well (Anderson et al. 1994)

Further research by Schilling et al. (2014) indicates that, while retrieval-induced forgetting impairs recall for semantically-related practiced items, if the retrieval-induced forgetting final test utilizes item-specific cues that are less general, semantically-related items that are not practiced in the study phase receive increased activation that facilitates, rather than inhibits, recall. Thus, increased competition for practiced items promotes activation of non-practiced items, indicating a beneficial element of retrieval-induced forgetting only when the elicitation cue is item-specific. Schilling et al. (2014) propose a practical rationale for this combination of inhibition and enhanced specific recall, wherein inhibitory control facilitates the active suppression of negative or unpleasant memories, supporting prior findings that greater working memory is found in individuals with increased retrieval-induced forgetting.

Neuroimaging research provides specific neural signals that are potentially associated with retrieval-induced forgetting, which researchers Wimber et al. (2015) define as “gradual suppression” (588). During a retrieval-induced forgetting task, Wimber et al. (2015) report that neural signals to terms that are semantically related to the targets receive activation during the study period but are suppressed in below-baseline levels during the target recall period. In accordance with performance-based literature, these results indicate that retrieval-induced forgetting has potential neurological as well as behavioral correlates. Thus, Wimber et al.’s (2015) assertion that such inhibitory processes in recall “adapt[s] the landscape of memory to the demands of mental life” (589), provides an adaptive rationale for their neural findings. However,

further testing is necessary due to the weakness of the association found between suppression and forgetting (Wimber et al. 2015).

In addition to confirming the utility of retrieval-induced forgetting as an adaptive process in neurotypical individuals, it is important to examine the effect in clinical populations, especially those in which memory has sustained significant functional changes. As previously stated, many individuals with autism report experiences of intense anxiety, for which retrieval-induced forgetting has been studied. Researchers Law et al. (2012), reveal that high state anxiety negatively correlates with retrieval-induced forgetting, indicating that, while the exact mechanism cannot be determined, anxiety lends itself to a decreased ability in suppressing items. These findings are also supported by the Attentional Control Theory, which posits that inhibitory abilities are diminished when anxiety is present (Law et al. 2012). Due to the causal relationship between sensory overresponsivity and anxiety across children with autism, attention deficit and hyperactivity, and neurotypical development (Lane et al. 2012), understanding how anxiety affects memory is imperative for understanding retrieval-induced forgetting in autism.

It is necessary to understand how retrieval-induced forgetting impacts extreme manifestations of stress outside a quotidian basis, beyond simply establishing the role of anxiety in both autism and retrieval-induced forgetting. Of the clinical populations studied for this phenomenon, individuals with posttraumatic stress (PTS), demonstrate the greatest marked differences in recall. In an initial study, Amir et al. (2009) reveal that individuals with a diagnosis of PTS are less successful at recall for a practiced list of words, implying that rehearsal is a less effective strategy for recall. Additionally, the PTS and traumatized but not diagnosed groups exhibit diminished performance of the retrieval-induced forgetting phenomenon, likely, due to decreased inhibitory abilities, specifically, in associative memory. Similarly, Catarino et

al. (2015) assert that, in a test of memory suppression, individuals with PTS display less inhibitory control for intrusive memories than non-PTS diagnosed individuals, with increased severity of PTS symptoms corresponding to decreased suppression. Additionally, self-reports of thought-control indicate that individuals with diminished abilities to inhibit intrusive memories experience less suppression-induced forgetting. These findings are corroborated by Sullivan et al. (2019), who determine that trauma-exposure, regardless of PTS diagnosis, curtails abilities to suppress negative content.

While understanding the role of traumatic stress on retrieval-induced forgetting reveals integral underpinnings of memory recall in clinical populations is key, examining how retrieval-induced forgetting is expressed in situations involving non-traumatic stress is equally imperative. For instance, researchers Koessler et al. propose that differing degrees and levels of stress mediate encoding and, depending on the type of memory, retrieval as well (2009). In addition, Koessler et al. determine that individuals who experience quotidian, non-traumatic stress do not display retrieval-induced forgetting (2009). However, Koessler et al. (2009) are quick to imply that this absence of retrieval-induced forgetting after stress may only be apparent in short-term episodic memories, likely as a result of contextual binding processes in which the surrounding context is cognitively attached to the subsequent memory of the stimuli or event. In later work, Koessler et al. (2013) reveal that elimination of retrieval-induced forgetting effects due to stress is a cognitive, as opposed to purely biochemical process. After oral administration of cortisol, meant to mimic some, though not all, of the body's physical responses to stress, state anxiety exhibits a greater effect than cortisol on retrieval-induced forgetting. Thus, retrieval-induced forgetting under stress can be described as an experiential, ontological, and situational phenomenon, as opposed to a strictly lab-induced one (Koessler et al. 2013). Given the

considerable discrepancies between experimental designs and real-life experiences, both in autism and memory research, the necessity of context to elicit a given memory process is crucial.

Despite the multitude of findings regarding retrieval-induced forgetting and its effects upon anxiety, stress, and PTS, no work has yet examined whether individuals with autism display retrieval-induced forgetting. Given literature suggesting that anxiety and stress, both of which are common experiences among individuals with autism, diminish the effects of retrieval-induced forgetting, one would assume that autism propagates a similar decrease of the phenomenon. Based on this theoretical conclusion, the following investigation seeks to understand how individuals with autism show effects of retrieval-induced forgetting, and how they perceive stress to impact their memory. To test this assumption, a retrieval-induced forgetting task was administered to individuals with autism recruited from the Claremont Colleges. Additionally, participants were interviewed about their experiences regarding temporary retrograde amnesia, termed temporary forgetting in the survey. This phenomenon is described by individuals with autism but not addressed in the literature. The interview responses were used along with statistical analyses of the retrieval-induced forgetting task to interpret the findings. Ensuing results will add to the body of knowledge regarding retrieval-induced forgetting and emphasize the importance of understanding both the experimental and experiential elements of individuals with autism and how combining both personal narratives with scientific research validates, clarifies, and enhances the existing literature.

Hypothesis and Research Aims

I hypothesize that individuals with autism will experience a decreased retrieval-induced forgetting effect compared to those without autism. This prediction follows from previous work showing that recall of a specific item, encoded in persons with autism via item-dependent and

not relational processing, will not inhibit semantically related items in the same manner. Thus, I predict that, in individuals with autism, the day's events, stored as item-dependent processing, may not be fully encoded until a later time (Bowler et al. 2011, Koessler et al. 2009). Therefore, I assume that individuals with autism will have decreased retrieval-induced forgetting. Additionally, I predict that, according to participant responses on a survey about memory, stress and delayed item-dependent encoding will be what render the day's events inaccessible. As Bowler et al. indicates individuals with autism rely upon item-dependent processing more than relational processing (2011), while Schilling et al. (2014) assert that item-specific cues increases activation for unpracticed semantically related items. Therefore, given that individuals with autism rely more on item-dependent processing, the semantic effects created by retrieval-induced forgetting paradigms will be rendered less effective, especially if item-specific cues are used. If this reasoning holds, then the target will recall to the same degree both the unpracticed items and practiced items, regardless of semantic relation to the target. Temple Grandin (2008), in her autobiography, also asserts that "repression [in memory] does not occur" (219), which, when combined with item-dependent processing research, indicates that the inhibitory control mechanism of retrieval-induced forgetting remains ineffective for individuals with autism at both an emic and ontologically-observed level. Additionally, Koessler et al. assert that stress eliminates the retrieval-induced forgetting effect among neurotypical controls and may affect encoding abilities (2009). Given the hypothesis regarding baseline memory for items in autism and encoding differences, this suggests that individuals with autism will, under stress, also show a lack of retrieval-induced forgetting.

Finally, I assume that individuals with autism will, on a survey, report needing lower levels of stress for an effect on memory to occur, and that more individuals with autism will be able to recollect instances of temporary forgetting compared to the non-autism group.

Method

Participants

All procedures were approved by the Scripps College Institutional Review Board and met ethical requirements under The Belmont report (1978) and Declaration of Helsinki (2013). Participants were 12 students over eighteen years of age who currently attend the Claremont Colleges and self-disclosed a diagnosis of autism or lack thereof. In the final analysis, two participants from the non-autistic group were excluded due to technical errors in data collection, leaving a total of 10 participants, 5 in the autistic group and 5 in the non-autistic group.

Materials

Materials included a 60-slide PowerPoint presentation with 6 examples for each of 10 categories, for which 2 served as fillers and 2 Qualtrics surveys that targeted a given subset of the categories for stem-completion and total recall. The materials for the category-item word pairs were taken directly from Anderson et al.'s 1994 study on retrieval-induced forgetting. Analysis of the data relied on three distinct conditions; 1) practiced items, for which participants filled out a stem-completion survey prior to final testing; 2) unpracticed items from the practiced category (here on out referred to as practiced category), which were items from the same category as the stem-completion items but which were not included in the practice survey; and 3) unpracticed category, which included entire categories of stimuli not included in the practice survey. For instance, one of the categories was fruit, for which the exemplars were orange, nectarine, pineapple, banana, lemon, and cantaloupe. Participants would receive a stem-

completion survey with the pair fruit: or___, for which they would need to write in the rest of the item, in this case, orange. Then, after a 20-minute delay, the participant would be given a recall test, in which they would need to recall as many members of a category as they could for all eight categories. The word orange would be coded as practiced item, the word banana would be coded as practiced category (since fruit was a practiced group but not that specific example), and words from the hobby category would be coded as unpracticed category. Each condition contained the following number of exemplars: 12 words for practiced items, 12 words for practiced category, 24 words for unpracticed category.

Finally, one Qualtrics survey with seven questions on memory and stress as experienced by the participant was created by the researcher. The questions were chosen to determine 1) whether transitory retrograde amnesia is specific to individuals with autism or more generally applicable, 2) when this amnesia occurs, what specifically is forgotten (*i.e.* what type of memory process is implicated), and 3) how long it takes for items forgotten due to stress to return. The basis for all questions was a combination of personal testimony from friends or acquaintances of the researcher and existing research on specific memory processes.

All materials can be found in greater detail in the appendices.

Procedure

Participants were sent a private Zoom link by the researcher, through which the entire experiment was conducted. First, participants were asked to read and complete the consent form, which they then emailed back to the researcher prior to starting the experiment. Next, they were shown the 5-minute PowerPoint of category and item word pairs, after which they were asked to fill out a stem-completion practice survey in Qualtrics. Assignment of categories to the practiced and non-practiced conditions was counterbalanced between participants. Within the practiced

categories, assignment of words to the practiced and non-practiced conditions was counterbalanced between participants. Participants were then given a 20-minute break, in which they turned off their camera audio and video, in place of a filler activity. After said break, the participants were asked to complete a test survey on Qualtrics, in which they listed, under each category given, all items they could recall from said category which they had seen in the PowerPoint. For example, if the category was fruit, participants were scored on how many of the following items they recalled: orange, nectarine, pineapple, banana, lemon, and cantaloupe. Participants were given one of four possible test surveys, across which order of category presentation was counterbalanced. Finally, participants were asked to complete a seven-question survey on Qualtrics asking about their experience with stress and memory, specifically, whether the former caused them to forget anything and when the memory returned. To conclude, participants were emailed the debriefing form in addition to receiving a verbal explanation of the study, were paid $15 on Venmo, and were thanked for their time and participation.

Results

Retrieval Induced-Forgetting and Stress

Data from the memory task were organized into three categories: practiced items, non-practiced items from practiced category, and non-practiced category. A summary of the data collected for each category, organized by group, can be found in *Figure 1*. Additionally, paired samples t-tests were conducted for each group separately in order to compare recall of the three categories of words.

The paired sample t-tests run on the three categories of the autistic group (see *Table 2*) indicate that recall for practiced items was higher than baseline, with practiced items recalled more than non-practiced items from the practiced category (t (4)= 5.807, p = 0.004) and more

practiced items than the non-practiced category items (t (4) = 5.751, p = 0.005 see *Table 2* and *Figure 1*). The autism group also demonstrated a marginal retrieval induced forgetting effect, with non-practiced items from the practiced category recalled less than items from the non-practiced category (t (4) = -2.07, p = 0.108). The control group recalled more practiced items than items from the non-practiced category (t (4) = 2.860, p = 0.046 see *Table 3* and *Figure 1*); however, the control group yielded decreased evidence of inhibition (t (4) = 1.37, p = 0.243). Although a retrieval-induced forgetting exists within the autism group and less so in the control group, six different paired samples t-tests yielded no such result between groups (see *Figure 1).*

Additional analyses were conducted using a paired samples t-test between groups on participant ratings of stress strength required to affect memory (t = 0.232, p = 0.828 see *Figure 2*), although findings were not significant.

Emic Experience of Stress and Memory

Participant responses to a survey on stress's effect on their memory were organized first by group and whether they reported experiencing stress effects on their memory and/or temporary forgetting (see *Table 5*), then, in the groups who did experience amnesia, by how long it took said memory to return. Finally, individual descriptions of stress affecting memory and specific examples, including temporary forgetting, when applicable, were included for each participant (see *Table 6* and *Table 7*). The autism group varied in how long it took their memories to return after stress-induced forgetting, with 2 participants reporting it within 24 hours, 1 within 1 hour, 1 who did not experience temporary forgetting, and 1 who said it could be within 1, 24, or 72 hours depending on what was forgotten (see *Table 6*). Responses also varied for the control group, with 2 participants reporting memory return within 24 hours, 1 within 1 hour, 1 longer than 72 hours, and 1 who did not experience temporary forgetting (see

Table 7). Two individuals from the autism group reported that stress caused them to forget "basic life things" or "routine knowledge," another participant from the same group indicated that stress or anxiety caused forgetting of "contextual details," and a final participant from the autism group recalled that they would "lose days and then remember them later" (see *Table 6*). Participants from both the autism and control groups indicated that stress-induced forgetting occurred during tests or when their response required a sense of urgency (see *Table 6* and *Table 7*). Finally, one participant from the autism group reported "short-term memory problems in the days following [the stress] . . . when overwhelmed, can fail to remember information – often associated with loss of language. . . [and] working memory impeded" (see *Table 6*) Although no statistical analyses were run on the responses, their significance to preserving the emic experience of individuals with autism in clinical research are explored more deeply in the discussion.

Discussion

General Discussion

For this study, I hypothesized that individuals with autism would show a decreased to non-existent retrieval-induced forgetting effect compared to non-autistic participants, meaning that the autism group would recall practiced items and items from the non-practiced category to a similar extent, as well as recalling unpracticed items from the practiced category to a similar degree as items from the non-practiced category. The results indicate that neither group exhibited a strong forgetting effect, but that inhibitory effects were stronger for the autism group than the control. This analysis does not support my hypothesis; however, it is the first study to indicate that individuals with autism do exhibit the retrieval-induced forgetting effect.

Retrieval-Induced Forgetting

In contrast to the hypothesis, individuals from the autism group showed retrieval-induced forgetting, while those in the control group did not. Although this outcome is the first study to illustrate a retrieval-induced forgetting effect for autism specifically, the small sample size – ten participants total, five in each group – indicates that further iterations of this study are necessary both to reproduce and establish the phenomenon. Additionally, the retrieval-induced forgetting paradigm was conducted in both groups under baseline conditions only. Given the second purpose of the study, to understand how stress affects memory in individuals with autism, future iterations of this study should be conducted using a retrieval-induced forgetting paradigm under stressful conditions. According to Koessler et al. (2009), retrieval-induced forgetting is diminished under stress in non-autistic individuals; thus, repeating this study's experimental methodology for both an autism and control group would be a logical next step. Moreover, understanding how retrieval-induced forgetting manifests in autism under stress may reveal whether this memory phenomenon is a possible mechanism for the temporary forgetting reported by individuals within this study. In a retrieval-induced forgetting task conducted under stress, I would predict individuals with autism to exhibit a larger elimination of retrieval-induced forgetting than non-autistic individuals, as item-dependent versus semantic processing does not appear to impact retrieval-induced forgetting as much hypothesized for this study.

Stress and Memory

Although no significant findings arose from a comparison of the control and autism groups' rating of stress strength required to affect memory, the small sample size is a potential source of error for said results. There was a wide range among participants in both groups regarding strength of the stress, with members of both groups giving the lowest score possible, and others rating on the higher end of the scale. Thus, these insignificant data could be the result of outliers,

although a larger sample size is necessary for a definitive answer. Additional iterations of the study could also use galvanic skin response during a retrieval-induced forgetting task under stress or another physiological measure to corroborate subjective ratings from the participants.

Emic Experience of Stress and Memory

Although some responses were similar between groups, answers to the survey pertaining to the effect of stress on memory were qualitatively different in the autism group. For instance, while both groups reported that stress over an upcoming exam induced temporary amnesia, only the autism group described stress-induced impairments of working memory, short-term memory, or language. Additionally, only the autism group reported temporary forgetting to encompass "routine" or "basic" life skills, for which examples included but were not limited to driving a car or remembering to eat.

Only the autism group noted that entire events were forgotten during times of stress, which, combined with findings of Southwick et al. (2011) on diminished episodic memory capacity in autism, indicate that stress may have a variety of effects on specific memory types in autism which differ from those without autism. Lind et al.'s (2014) reports that individuals with autism may utilize different processes of generalization could be a possible explanation for why individuals from the autism group described forgetting routine life skills. For instance, during one session, a participant from the autism group pointed out that one of the categories in the retrieval-induced forgetting task was incorrect, stating that all other categories listed direct exemplars, while one, the leather category, listed, not examples of different types of leather, but examples of different ways leather can be used. To illustrate their point, the participant asserted that all bananas are fruits – fruits was one category – but not all purses are made of leather. This observation indicates a possible difference in the way the participant generalizes semantic

categories. Bowler et al. (2011) addresses this in a chapter on memory and autism, proposing that individuals with autism rely on item-dependent as opposed to semantic processing, while Temple Grandin corroborates this experience in her autobiography, asserting that as a child, she first learned to distinguish cats and dogs, not by their behavior, but by their size (2008). Combined with the autistic participant's report that the leather category felt wrong to them, these first-person descriptions indicate what clinical research has only suggested: category processing may vary between individuals with autism and those without. Although further data is necessary to determine whether the participant's observation about the retrieval-induced forgetting categories is due to a difference in relational processing, future iterations of this study should measure whether participants from both groups – autistic and non-autistic – exhibit item dependent or semantic processing.

Moreover, one of the participants from the autism group also reported that stress induced short-term memory, working memory, and "loss of language" challenges. Further investigation, likely utilizing a retrieval-induced forgetting paradigm conducted under stress, is necessary to determine 1) whether this phenomenon is unique to individuals with autism, unique to non-neurotypical individuals, or experienced by neurotypical participants as well, and 2) what level of stress is required to cause these processing changes.

Finally, the inclusion in these findings of first-person accounts of temporary forgetting of individuals with autism marks an imperative first step in centering autistic voices and experiences in clinical research. In her autobiography, Temple Grandin (2008) describes her "frustration of not being able to talk . . . [but] understand[ing] what people said" (33-34). The erroneous assumption Grandin remarks on, that inability to produce spoken language corresponds to an inability to comprehend language or to think, illustrates the extent to which

autistic voices are not only silenced, but presumed nonexistent in the first place. The inclusion in this study of direct quotes and first-person accounts from individuals with autism illustrates how clinical research can and should be supplemented by the experiences of the group being studied. Therefore, further improvements on this study should also include qualitative first-person data in addition to clinical findings, thereby legitimizing and re-centering autistic individuals in explorations of their experience.

Future studies should use the same questions from this survey but provide a more rigorous definition of forgetting and temporary forgetting, to ensure participants understand there is a difference, for the purposes of this research, between the two. Additionally, a checklist of items that stress causes the participant to forget could be included, with an option for describing or adding an item if it does not appear on the list. Finally, the question regarding how long it takes for a temporarily forgotten idea to return, after experiencing stress, should be reconfigured according to the item forgotten. For instance, participants could select a time period for different types of memory loss, such as loss of an event, loss of specific information, loss of routine knowledge, and any other applicable categories. One participant acknowledged that their memories returned at different moments based on what type of information was forgotten, thus, further exploration as to what category of memory is implicated is necessary.

Conclusion

This study is the first to establish that individuals with autism show a retrieval-induced forgetting effect, a phenomenon not previously examined in clinical literature. Findings also suggest that stress-induced transitory retrograde amnesia in individuals with autism may differ from the same stress-induced temporary forgetting exhibited by non-autistic individuals, and that distinct memory types may contribute to this variation. Additionally, participant responses to the

retrieval-induced forgetting task from the autism group indicate potential differences in processing, wherein individuals with autism may rely on item dependent, as opposed to semantic relational processing. Finally, the incorporation of first-person narratives with clinical data affirms the necessity of including emic experiences of individuals with autism in clinical research, both to legitimize and prioritize autistic voices in psychological literature.

References

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Washington, DC: Publisher.

Amir, N., Badour, C. L., & Freese, B. (2009). The effect of retrieval on recall of information in individuals with posttraumatic stress disorder. *Journal of Anxiety Disorders*, *23*(4), 535-540.

Anderson, M. C., Bjork, R. A., & Bjork, E. L. (1994). Remembering can cause forgetting: retrieval dynamics in long-term memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *20*(5), 1063.

Asperger, H., & Frith, U. T. (1991). 'Autistic psychopathy' in childhood.

Badone, E., Nicholas, D., Roberts, W., & Kien, P. (2016). Asperger's Syndrome, Subjectivity and the Senses. *Culture, Medicine, and Psychiatry*, *40*(3), 475-506.

Barendse, E. M., Hendriks, M. P., Jansen, J. F., Backes, W. H., Hofman, P. A., Thoonen, G., Kessels, R. P., & Aldenkamp, A. P. (2013). Working memory deficits in high-functioning adolescents with autism spectrum disorders: neuropsychological and neuroimaging correlates. *Journal of neurodevelopmental disorders*, *5*(1), 14.

Bowler, D. M., Gaigg, S. B., & Lind, S. E. (2011). Memory in autism: Binding, self and brain. 316-346.

Catarino, A., Küpper, C. S., Werner-Seidler, A., Dalgleish, T., & Anderson, M. C. (2015). Failing to forget: Inhibitory-control deficits compromise memory suppression in posttraumatic stress disorder. *Psychological science*, *26*(5), 604-616.

Colvert, E., Tick, B., McEwen, F., Stewart, C., Curran, S. R., Woodhouse, E., ... & Ronald, A. (2015). Heritability of autism spectrum disorder in a UK population-based twin sample. *JAMA psychiatry*, *72*(5), 415-423.

Grandin, T. (2008). *Thinking in pictures, expanded edition: My life with autism*. Vintage.

Green, S. A., & Ben-Sasson, A. (2010). Anxiety disorders and sensory over-responsivity in children with autism spectrum disorders: is there a causal relationship?. *Journal of autism and developmental disorders*, *40*(12), 1495-1504.

Green, S. A., Hernandez, L., Tottenham, N., Krasileva, K., Bookheimer, S. Y., & Dapretto, M. (2015). Neurobiology of sensory overresponsivity in youth with autism spectrum disorders. *JAMA psychiatry*, *72*(8), 778-786.

Kanner, Leo. (1943). Autistic disturbances of affective contact. *Nervous child*, *2*(3), 217-250.

Koessler, S., Engler, H., Riether, C., & Kissler, J. (2009). No retrieval-induced forgetting under stress. *Psychological Science*, *20*(11), 1356-1363.

Koessler, S., Steidle, L., Engler, H., & Kissler, J. (2013). Stress eliminates retrieval-induced forgetting—Does the oral application of cortisol?. *Psychoneuroendocrinology*, *38*(1), 94-106.

Lane, S. J., Reynolds, S., & Dumenci, L. (2012). Sensory overresponsivity and anxiety in typically developing children and children with autism and attention deficit hyperactivity disorder: cause or coexistence?. *American Journal of Occupational Therapy*, *66*(5), 595-603.

Law, R., Groome, D., Thorn, L., Potts, R., & Buchanan, T. (2012). The relationship between retrieval-induced forgetting, anxiety, and personality. *Anxiety, Stress & Coping*, *25*(6), 711-718.

Lind, S. E., Bowler, D. M., & Raber, J. (2014). Spatial navigation, episodic memory, episodic future thinking, and theory of mind in children with autism spectrum disorder: evidence for impairments in mental simulation?. *Frontiers in Psychology*, *5*, 1411.

LoParo, D., & Waldman, I. D. (2015). The oxytocin receptor gene (OXTR) is associated with autism spectrum disorder: a meta-analysis. *Molecular psychiatry*, *20*(5), 640.

Maister, L., & Plaisted-Grant, K. C. (2011). Time perception and its relationship to memory in autism spectrum conditions. *Developmental Science*, *14*(6), 1311-1322.

Maras, K. L., Gaigg, S. B., & Bowler, D. M. (2012). Memory for emotionally arousing events over time in Autism Spectrum Disorder. *Emotion*, *12*(5), 1118.

Sandin, S., Lichtenstein, P., Kuja-Halkola, R., Larsson, H., Hultman, C. M., & Reichenberg, A. (2014). The familial risk of autism. *Jama*, *311*(17), 1770-1777.

Schilling, C. J., Storm, B. C., & Anderson, M. C. (2014). Examining the costs and benefits of inhibition in memory retrieval. *Cognition*, *133*(2), 358-370.

Southwick, J. S., Bigler, E. D., Froehlich, A., DuBray, M. B., Alexander, A. L., Lange, N., & Lainhart, J. E. (2011). Memory functioning in children and adolescents with autism. *Neuropsychology*, *25*(6), 702.

Strathearn, L. (2009). The elusive etiology of autism: nature and nurture?. *Frontiers in behavioral neuroscience*, *3*, 11.

Sullivan, D. R., Marx, B., Chen, M. S., Depue, B. E., Hayes, S. M., & Hayes, J. P. (2019). Behavioral and neural correlates of memory suppression in PTSD. *Journal of psychiatric research*, *112*, 30-37.

United States. National Commission for the Protection of Human Subjects of Biomedical, & Behavioral Research. (1978). *The Belmont report: ethical principles and guidelines for the protection of human subjects of research* (Vol. 2). Department of Health, Education, and Welfare, National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research.

Willey, L. H. (2014). *Pretending to be Normal: Living with Asperger's Syndrome (Autism Spectrum Disorder) Expanded Edition*. Jessica Kingsley Publishers.

Wimber, M., Alink, A., Charest, I., Kriegeskorte, N., & Anderson, M. C. (2015). Retrieval induces adaptive forgetting of competing memories via cortical pattern suppression. *Nature neuroscience*, *18*(4), 582.

World Medical Association. (2013). WMA Declaration of Helsinki-Ethical principles for medical research involving human subjects.

Table 1. Comparison of mean % recall for each of three conditions – practiced item, practiced category, and non-practiced category – for the control and autism groups.

Group	Recall % Practiced Item	SD	Recall % Practiced Category	SD	Recall % Non-practiced Category	SD
Control	80.00	24.01	30.00	27.39	47.50	12.36
Autism	86.67	15.14	35.00	19.00	54.17	15.02

Table 2. T values and corresponding two-tailed p values from paired samples t-tests run on the autism group.

Comparison	t	df	Sig. (2-tailed)
Practice Item- Non-Practiced Category	5.75	4	0.005
Practiced Category – Non-Practiced Category	-2.07	4	0.108
Practiced Item – Practiced Category	5.81	4	0.004

Table 3. T values and corresponding two-tailed p values from paired samples t-tests run on the control group.

Comparison	t	df	Sig. (2-tailed)
Practice Item- Non-Practiced Category	2.86	4	0.046
Practiced Category – Non-Practiced Category	-1.37	4	0.243
Practiced Item – Practiced Category	2.28	4	0.084

Table 4. T value and corresponding 2-tailed p value from a paired samples t-test comparing mean stress strength necessary to affect memory from the autism group and the control group.

Comparison	t	Sig. (2-tailed)
Autism - Control	0.232	0.828

Table 5. Comparison of number of individuals who report experiencing temporary forgetting for autism and non-autism groups.

Experiences Temporary Forgetting	Autism	Control
Yes	4	3
No	1	2

Table 6. Participant responses to questions about how stress affects their memory and experience of temporary forgetting for the autism group.

Participant Number	Memory returns	What was forgotten	Stress and memory	Temporary Forgetting
1	Within 24 hours	Tasks on mental to-do list, details of task at hand, normal routine knowledge (e.g. how to drive a car)	In a particularly stressful event, couldn't remember event (memories didn't form or was having trouble with recall), also had short-term memory problems in days following. When overwhelmed, can fail to remember information - often associated with loss of language - working memory impeded	Very often during trivia games I will only remember once the urgency/time pressure is gone

2	Within 1 hour	Stress and Anxiety often cause me to temporarily forget things.	I found it more difficult to remember things until after I submitted the test.	I feel like I don't know what the answer is and then once everything is turned in or no longer important, I remember.
3	Within 72 hours/depends on the memory	Remembering to eat other basic life things/ like all information when I'm taking a test, certain traumas that I later recovered	I often forget things when I'm stressed/ or get overwhelmed so I feel like I remember it but I can't reach it. Or I'm just unsure	I really don't remember my experience well enough to describe it well. Often memories will kinda go away and come back, especially if their stressful. Or I loose days and then remember them later. Sorry I can't describe this better.
4	Within 24 hours		I cannot say in particular because I cannot call to mind any specific instance. But it is harder for me to think straight when stressed, so it seems very likely to me that I have failed to call to mind relevant contextual information when stressed in the past.	This happens frequently with respect to things like remembering a song, a piece of code, a piece of media, etc.
5	N/A	If I was focused on/stressed about some event, I might forget another obligation unrelated to the stressor	I noticed I was constantly recalling small and sometimes insignificant details	N/A

Table 7. Participant responses to questions about how stress affects their memory and experience with temporary forgetting for non-autism group.

Participant Number	Memory returns	What was forgotten	Stress and memory	Temporary Forgetting
1	N/A	For class exams, a concept or idea might be at the tip of my tongue but I can't remember the whole thing if I stress-studied/crammed the night before.	Depends, sometimes I forget things but sometimes I remember them better. If stressed, I might not remember it well in the long-term but i might in the short-term	N/A
2	Within 24 hours	In stressful times I forget long-term obligations, like a lunch meeting with a friend	days blur together during stressful times. People seem less kind or patient when I'm stressed	I forget people's names or specific words when particularly stressed
3	Within 24 hours	Specific harmful interactions with other people or details of past relationships, etc. also daily activities like meetings, commitments, homework assignments, due dates or other important dates, etc	Forgetting big spans of time, not remembering what i did earlier in the day, not remembering conversations, mixing things up really easily, omitting details of stressful events	I experience this a lot with trying to remember things i was supposed to do in a day or say to someone, also on a larger scale therapy has caused me to re-remember details of my life from the past that I had blocked out or temporarily forgotten
4	Within 1 hour	Answers for tests at school, to do tasks that other people asked me to complete	Sometimes sharpens certain things if my stress focuses me, but then I completely forget other small things I should've remembered because I so	Doesn't usually happen with big things, will just forget to do something and remember later or remember a test answer after the test ends

			heavily focused on other aspects	
5	Longer than 72 hours	N/A	Details are harder to remember	I might mention someone in a story but forget their name, and only remember later.

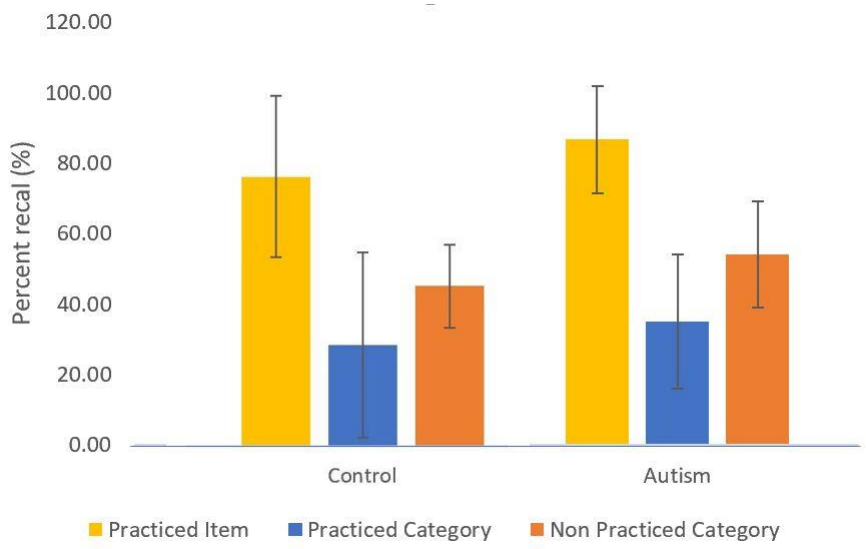

Figure 1. Comparison of percent recall across three types of stimuli – practiced item, practiced category, and non-practiced category – in non-autism and autism groups (non-autistic practiced item M = 80.00%, non-autistic practiced category M = 30.00%, non-autistic non-practiced category M = 47.50%, autism practiced item M = 86.67%, autism practiced category M = 35.00%, autism non-practiced category M = 54.17%).

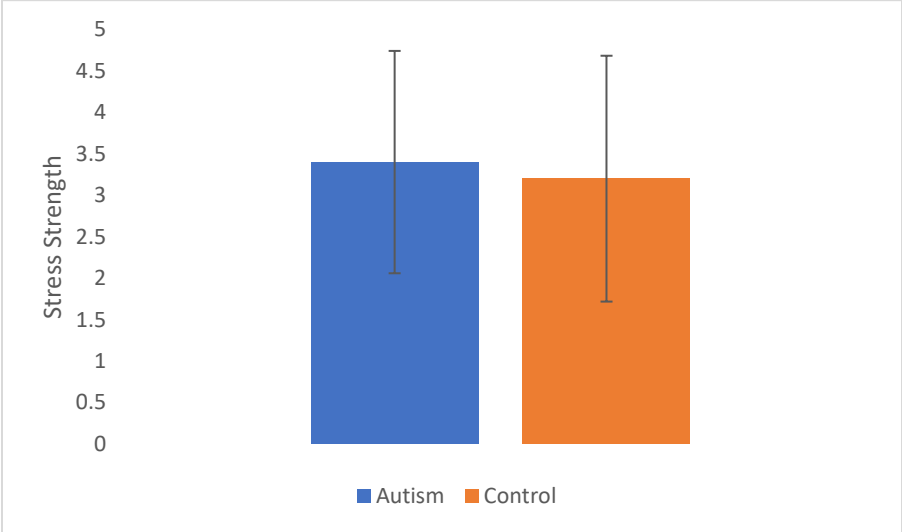

Figure 2. Comparison of stress strength required to affect memory for autism and non-autism groups ranging from 1 to 5 (autism stress strength M = 3.2, non-autism stress strength M = 3.4).

Appendix A: Retrieval-Induced Forgetting Materials (Anderson et al. 1994).

Category	Exemplar Set 1	Exemplar Set 2
Set A: Strong		
Fruits	Orange, nectarine, pineapple	Banana, cantaloupe, lemon
Leather	Saddle, gloves, wallet	Shoes, belt, purse
Set A: Weak		
Trees	Palm, hickory, willow	Poplar, sequoia, ash
Professions	Tailor, florist, farmer	Critic, grocer, clerk
Set B: Strong		
Drinks	Bourbon, scotch, tequila	Brandy, gin, rum
Hobbies	Gardening, coins, stamps	Ceramics, biking, drawing
Set B: Weak		
Metals	Chrome, platinum, magnesium	Mercury, pewter, tungsten
Weapons	Hammer, fist, lance	Rock, arrow, dagger

Appendix B: Stress and Memory Survey Materials:

Survey questions:
I will be asking after each survey question how confident they are on a scale of 1-3 of their answer.

I would like to ask you some questions about your non-traumatic memories of everyday events that may have been experienced as stressful. Examples of non-traumatic stress could include events that left you feeling especially drained or exhausted, such as having a lot of homework or professional work, feeling emotional distress from a cold or flu, or getting little sleep and having a very busy day.

- Has stress ever influenced your memory?
- If yes, in what way did you notice a change in your memory?
- If yes, has stress ever caused you to forget something?
- What did it cause you to forget?
- Has stress ever caused you to forget a specific event?

If you answered yes to any of the above, please continue to the next section. If you answered no, you are done with the survey.

- Have you ever experienced temporary forgetting (aka, you can't remember something but the memory returns at a later point)? If so, please elaborate this experience in the box below.
- How strong does stress have to feel for it to impact your memory? Please rate below on a scale of 1 (not strong) to 6 (most strong).
- If you have ever experienced temporary forgetting, when did the memory return?
    - Within 1 hour
    - Within 24 hours
    - Within 72 hours
    - Longer than 72 hours