Psychological Stress and Language Processing in School-Aged Children

Le stress psychologique et le traitement du langage chez les enfants d'âge scolaire

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Abstract

In this review article, the contribution of psychological stress to language-processing difficulties is discussed and applied to the demands of the school setting. Specifically, processing efficiency theory contends that worries have an effect on the working memory system and thus influence task efficiency: both phonological loop capacity and central executive resource utilization become impaired. In addition, research linking the physiological events of psychological stress to disruption of the hippocampal memory system is examined. The hippocampal memory system is responsible for the formation of declarative memories, principally semantic and episodic memories. It is suggested that psychological stress can lead to semantic disorganization and ultimately word-retrieval difficulties. Suggestions for intervention, assessment, and future directions are also outlined.

Abrégé

Le présent exposé de synthèse examine la façon dont le stress psychologique intervient dans les difficultés de traitement du langage en fonction des exigences du milieu scolaire. Plus précisément, la théorie de l'efficacité du traitement mental soutient que les soucis ont un effet sur la mémoire opérationnelle et influent ainsi sur l'efficacité avec laquelle les tâches sont accomplies : la capacité de la boucle phonologique et l'utilisation des ressources de l'administrateur central sont altérés. En outre, l'article examine les recherches qui établissent un lien entre les manifestations physiologiques du stress psychologique et la perturbation de la mémoire hippocampique. Le système mnémonique hippocampique est responsable de la formation des éléments de mémoire propositionnelle, principalement des éléments des mémoires sémantique et épisodique. On laisse entendre que le stress psychologique peut engendrer une désorganisation sémantique et éventuellement, des troubles de repérage lexical. On y propose aussi des moyens d'intervention et d'évaluation ainsi que des orientations futures.

Keywords: psychological stress, language processing, school-aged

The negative contribution of psychological stress to language processing has not been extensively researched in the area of speech-language pathology. This situation is surprising given the growing body of literature that links psychological stress and related conditions to decrements in two cognitive modules that are crucial to competent language processing: long-term and working memory (e.g., Eysenck, 1996; Sapolsky, 1998). The present review has three purposes: (a) to demonstrate the harmful link between psychological stress and memory over the short and long term, (b) to demonstrate that this link to memory can inhibit proficient language processing, and (c) to discuss the implications of this relationship for speech-language pathologists who assess and treat school-aged children.

What Is Psychological Stress?

Psychological stress is often discussed in education as an intrusive condition that inhibits learning in the classroom. Jensen (1998) calls psychological stress "the single greatest contributor to impaired academic learning" (p. 52). Other researchers have refined the argument a step further and labeled this physiological response as a possible contributor

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to a learning disability. For example, Smith (1998) explains that the characteristics of the student (learner), curriculum variables (task), and family and school pressures (setting) are factors that contribute to mild, moderate, or severe levels of learning impairment. She suggests that the "personality and social emotional adjustment" of the learner as well as the "emotional climate" of the setting that the child is raised in influence information processing within the classroom.

The latter factor, the setting, has been studied extensively as it relates to impaired academic performance. Researchers often study the intellectual, academic and social-emotional development of children in adverse emotional climates. These environments induce powerful psychological stress within its residents and can often lead to mood disorders such as anxiety, depression and fear. Osofsky (1995) studied an extreme example of an adverse emotional climate. This researcher documented a large percentage of children living in "urban war zones" who have witnessed murders and serious assaults. These children showed increased anxiety, depression, sleep disturbances, aggression and withdrawal, which translated into decreased concentration and motivation in the classroom. Other highly charged emotional climates within the home can be detrimental to intellectual, academic and social-emotional development: physical and sexual abuse (Lisak & Luster, 1994); absence of a parent for long periods of time (e.g., divorce) (Svanum, Bringle, & McLaughlin, 1982); neglectful parenting (Kendall-Tackett & Eckenrode, 1996); parental substance abuse (Moss, Vanyukov, Majumder, Kirisci, & Tarter, 1995); paternal job/income loss (McLoyd, 1989); and authoritarian style of parenting (Dornbusch, Ritter, Leiderman, Roberts, & Fraleigh, 1985). Given these findings, it is important to know what stress is in order to develop effective strategies to deal with and recognize it in a classroom.

Physiologists and psychologists define stress as "the body's physiological response to a stressor, which is any event or change that requires adaptation" (Durand & Barlow, 1997, p. G-6). By this definition, psychological stress can be broken into two broad components: the psychological (determining if an event requires adaptation) and the physiological (physiologically adapting for action once an event is appraised).

The physiological response to a stressor is closely tied to the body's "flight or fight" system. This system prepares the body for emergency. When a threat is imminent, the two main decisions are fighting (when you assess an enemy to be weaker then you), or fleeing (when you encounter a bear, for example). To cope, the body switches its current equilibrium and priorities to a high physiological arousal to enable these functions. Major physiological events in the body include an increase in heart rate, blood pressure and respiration; an increase in blood sugar rates allowing rapid energy use; the thickening of blood to increase blood supply (red blood cells), to fight infections (white blood cells), and to halt bleeding quickly (platelets); a sharpening of the senses allowing swift responses; a prioritization of systems through an increase of blood flow to the peripheral muscles and heart, to motor and basic functions regions of the brain; an ensuing decreased blood supply to the digestive system and irrelevant brain areas (such as the speech areas); and the secretion of adrenaline, endorphins and other stress chemicals to fortify relevant systems (Ben-Shahar, 2003). These events boost a person's ability to respond to urgent situations.

This physiological reaction does not only occur in the presence of an environmental threat like a charging elephant or a runaway truck, it also occurs as a result of self-threatening thoughts such as a divorce, death of a loved one, or failed expectations. This perceived threat to one's well-being is termed a psychological stressor as it is generated by the subjective cognitions of the person. According to Lovallo (1997), psychological stressors have four key characteristics: 1) They achieve their threat value through subjective appraisals, not through their physical ability to do harm, 2) They are not equally stressful to all persons, 3) The ability to cope with perceived stressors is different among persons, and 4) The physiological response to psychological stressors is the same process we use to react to physical threats. It is this "psychological stress" from adverse experiences that can impact on many aspects of children's development, including academic success (Maughan & McCarthy, 1997).

While the physiological portion of the stress response has gained the lion's share of attention as it relates to impaired learning, the actual appraisal processes of psychological stressors are just as crucial to understanding learning interference and, eventually, deficits in language processing. Lazarus and Folkman (1984) describe how interactions with the environment generate emotions and produce "flight or fight" responses. First, there is a primary appraisal of an event that determines if it is a prospective threat to our beliefs and commitments. Then, if it is judged to be a danger to some aspect of our life, a coping process is initiated. Events judged as harmless are safely ignored and no further adaptive responses are initiated.

When an event is tagged as threatening, a simultaneous emotional reaction signals alarm and mobilizes further behavioural and psychological responses along with flight or fight activation. The goal of these behavioural and psychological responses is to lower the threat value of an agitating event. Lazarus and Folkman (1984) term these "coping behaviours". Psychological coping behaviours alter cognitions (e.g., "It's probably better that way anyhow.") and behavioural responses try to alter the environment (e.g., changing marks on a poor report card).

Once one of these coping strategies is utilized, Lazarus and Folkman (1984) suggest that a secondary appraisal is undertaken to reassess the event's threat in comparison with our new cognitions and environment. Therefore, our appraisal processes are recurrent, and our responses are continuously being modified as we deal with arising contradictions. The ultimate goal of this process is one of physiological and psychological restoration: reduce or eliminate the threat value of an event, reduce the negative

emotions to it, and therefore reduce the inner state associated with physiological stress reactions.

Psychological stress from adverse childhood experiences is closely linked with psychosocial disorders that children may experience (Maughan and McCarthy, 1997). Furthermore, Lovallo (1997) explains that emotional states such as depression, anxiety, fear and excitement are relatively similar and involve many of the same physiological responses found in the flight or fight system. According to Durand and Barlow (1997), the distinguishing variable among these related moods is the perceived sense of control one has over the emotive event. Excitement might be experienced with a rapid heart beat, sudden burst of energy, or butterflies in your stomach. For a person who is feeling well prepared — for example, a student before a big test who believes he or she is going to perform well — these feelings of excitement are enjoyable. Conversely, if students feel that they have little control over a future, undesirable event, these same feelings quickly turn to anxiety. Pupils who continually see their present life as threatening or dangerous to their world beliefs may begin to lose hope about ever controlling these threats and slip into a state of depression. The key concept to keep in mind is that excitement, anxiety, depression and fear are related at the physiological level and are distinguished at the cognitive level by the sense of control that is perceived.

This brief explanation of the psychological and physiological aspects of stress will be applied to their respective influences on memory in the forthcoming sections– specifically, the potential consequences on two information systems crucial in language processing: working memory and long-term memory.

The Relationship Between Psychological Stress and Impaired Working Memory

Working memory is closely related, but not identical, to the concept of short-term memory. In the school setting, Levine (1994) describes it as a "temporary way station, a place where ideas are stored while they are being developed further, manipulated, or used as part of an activity" (p. 63). Therefore, working memory is more than just short-term storage of auditory and visual information; it also contains a processing component.

Alan Baddeley (1986) integrated the auditory, visual and processing components into one working memory theory. This model has three major components: a central executive and two buffer systems that serve the executive. The executive is responsible for computational operations on information and for scheduling the allocation of attentional resources to various tasks at hand. At the service of the central executive are two storage components: the phonological loop and the visuospatial scratchpad. The former specializes in rote verbal rehearsal, which is used for the transient storage of speech-like information, and the latter is dedicated to the retention of visual and/or spatial information.

Though there is significant support for Baddeley's conceptualization of working memory, "general capacity theories" of working memory have empirical support (e.g., Cantor & Engle, 1993; Just & Carpenter, 1992). These "general capacity theories" define working memory as "information in long-term memory that has been activated above some resting level that makes it accessible to cognitive processes and procedures" (Cantor & Engle, 1993, p. 1111). They also posit that information units in long-term memory vary in terms of their level of activation and the total amount of activation that is available to the working memory system is limited. Thus, individual differences in working memory reflect individual differences in the total amount of processing resources available to each individual (Cantor & Engle, 1993). In addition, capacity theory views working memory as a single construct with general resources, rather than domain specific modules (Cantor & Engle, 1993). Often, supporters of the capacity theory model its theoretical assumptions in connectionist or connectionist-production system simulations (e.g., Just & Carpenter, 1992; MacDonald & Christiansen, 2002). Connectionists view cognitive modeling as a pattern of activation over a network of interconnected processing units or "neurons" (Medin & Ross, 1992). In sum, capacity theory deals centrally with the resources underlying working memory while assuming an underlying architecture based on connectionist principles (Just & Carpenter, 1992).

In the upcoming discussion on how stress and working memory interact, Baddeley's theory will be largely referred to as most researchers interested in stress and working memory have used this model to explain this relationship (e.g., Darke, 1988: Eysenck & Calvo, 1992; Rapee, 1993). However, capacity theory and its connectionist representations of working memory also have the potential to explain the effects of psychological stress on human information processing as the concepts of processing and capacity are central to these theories. As will be explained, processing and capacity are also key themes to how stress interacts with working memory. Capacity theories and their application to psychological stress will be revisited towards the end of this section.

The working memory system has been implicated in mediating the effects of high levels of stress on performance (Eysenck, 1992). Working memory is where we consciously perform our primary and secondary appraisals of threatening events and judge the consequences of our coping efforts (Lovallo, 1997). Thus viewed, working memory can be not only a victim of psychological stress, but also an initiator of the physiological stress response.

This involvement of working memory has been blamed for the inefficient processing of tasks in high stress or high anxiety situations. The major reason cited in research is that anxiety reduces the available capacity of working memory. How is this possible? One suggestion is that anxious individuals allocate more working memory resources to "worries" and other task-irrelevant thoughts than do non-anxious individuals. Worries represent an "attempt to engage in mental problem solving on an issue whose outcome

is uncertain but contains the possibility of one or more negative outcomes. Consequently, worry relates closely to fear processes" (Borkovec, 1983, p. 10, as quoted in Wells & Matthews, 1994, p. 148). This "mental problem solving" is similar to the appraisal and coping processes associated with psychological stress. Worrying has also been conceptualized as being more automatic in nature than conscious problem solving. Worries are described as "unwanted thoughts" that automatically enter consciousness and require mental control in order to suppress them (e.g., Klein & Boals, 2001). The key concept is that worrisome thoughts interfere with attention to the task at hand, thus reducing the working memory resources available for processing an activity.

Eysenck and Calvo (1992) differentiate between processing *efficiency* and processing *effectiveness* in their theory of how worrying affects working memory. Processing effectiveness is the success one has on the task at hand (i.e., the task score). Processing efficiency refers to the relationship between performance effectiveness and the amount of effort (or processing resources) invested in attaining that performance. In crude terms, Eysenck (1996) describes processing efficiency as "performance effectiveness divided by processing resources or effort." Thus, even when performance between two people is equal, the effort used in reaching a similar performance may be quite different.

This distinction between efficiency and performance is crucial to the "Processing-Efficiency Theory" formulated by Eysenck and Calvo (1992). The key idea in this theory is that worrying pre-empts some of the resources of the working memory system, thus impairing processing effectiveness. Anxious individuals are extra-sensitive to this allocation of resources, so they then allocate more effort to the task at hand in order to eliminate or reduce the worry. By increasing the amount of concentration they give to the task, they hope to reduce or eliminate worry.

It is assumed by the Processing-Efficiency Theory that it is the level of state anxiety, rather than trait anxiety, that is critical in determining individual differences in internal processing and performance (Eysenck & Calvo, 1992). Trait anxiety is regarded as a stable or enduring feature of personality; state anxiety is situational, or transitory. It is also assumed that state anxiety is determined interactively by trait anxiety and situational threat or stress (Eysenck & Calvo, 1992). However, researchers usually make no attempt in extricating their respective effects as they correlate as highly as 0.70 or more with each other (Eysenck, 1992). As it will be seen, attempts were not made to separate their respective effects in the upcoming studies.

The Processing-Efficiency Theory rests on three theoretical assumptions (Eysenck, 1996):

1. Worry processes utilize resources of the central executive and phonological loop.
2. Anxiety reduces working memory capacity available for performance of a task.
3. Anxiety usually impairs task efficiency more than task effectiveness.

These theoretical postulates have empirical support. Rapee (1993) tested the first assumption by giving participants tasks of different sorts and analyzed which ones decreased the frequency of worry-related thoughts. He found that "tasks which utilize both the central executive and the phonological loop of working memory are the most effective in reducing the ability to worry. Tasks which utilize solely the phonological loop seem to interfere with worrying with some degree, while tasks which utilize the visuospatial scratch pad and the central executive concerned with this slave subsystem seem to have little influence on worrying" (pp. 619-620). This finding supports "introspective" data that worry is primarily a verbal behaviour rather than visual (Borkovec & Inz, 1990).

Darke (1988) as well as MacLeod and Donnellen (1993) provide experimental support for the second assumption. Darke used a reading span task and a digit span task with highly anxious and low anxiety subjects in his experiment. The reading span task highly taxes working memory, whereas the digit span task is less demanding. In light of the different demands of each task on working memory, Darke predicted that anxiety would have a greater effect on the reading task rather than the digit span task. This prediction was confirmed by the finding that participants low in anxiety performed 68% better than the participants high in anxiety on the reading span task, but their performance was only 20% better on the digit span task. MacLeod and Donellen provided further empirical support for assumption two. A grammatical reasoning task was performed with participants who were classified as either high or low in trait anxiety. This task was specifically designed to make use of working memory by requiring the participants to maintain a low or a high memory load in the form of digits while carrying out the reasoning task. Predictions were verified when those high in trait anxiety performed much worse than those low in trait anxiety on the reasoning task with a high memory load, but there was practically no effect of trait anxiety with the low memory load. These two findings show that anxiety reduces working memory capacity available for performance on a task, especially challenging ones.

Support for the third assumption comes from research with participants evidencing sub-clinical anxiety. The Processing-Efficiency Theory predicts that individuals with high levels of anxiety will direct extra processing capacity to a task to maintain or improve performance. Elliman, Green, Rogers and Finch (1997) found that task accuracy, or effectiveness (in this case, the ability to detect a sequence of three odd or even numbers), did not differ significantly among high-, medium-, and low-anxious participants. However, the processing time, which represents efficiency, significantly increased as the task progressed for the high anxiety group, while processing times for the low and medium anxiety groups remained constant. This suggested that the high-anxious participants had to increase their processing effort (as indicated by longer processing times) in order to maintain accuracy. This finding is in harmony with previous research that

discovered that high-anxious individuals need longer time to process information on verbal memory tasks (e.g., Ikeda, Iwanga, & Seiwa, 1996).

What is happening to each working memory module in Baddeley's theory during anxious task performance under the Processing-Efficiency Theory? Elliman et al. (1997) suggest that the decrements to processing efficiency may be two-fold: "Subvocal pre-occupying cognitions preferentially consume resources in the articulatory loop [phonological loop]. Also, extra processing demands, in the form of extra effort, affect the central executive" (p. 34). If we remember that the central executive's role is to schedule the allocation of attentional resources, we can see two effects of anxiety on this component of working memory. Active recruiting and focusing of attentional resources both occupy the central executive and reduce the reserve of attentional resource. This should have a cascading effect should the demands of the task increase. Indeed, this is the case as adverse effects of worry on task performance are greatest on those tasks that are relatively difficult and require the most attention (cf. Sarason, 1984).

The power of the Processing-Efficiency Theory is that it allows us to consider the cognitive component of anxiety, a condition related to psychological stress. It was originally intended, as Eysenck (1992) explains, "to have general applicability, but may in practice have most relevance to cognitive-task performance, to high-anxiety in normal populations rather than clinical populations" (p. 14). Despite his reservations, it does seem that this theory has the potential to address the general relationships between cognition and emotion and could be reformulated to extend to other emotional states that are related to psychological stress. For example, Ellis and Ashbrook's (1988) resource allocation model proposes that individuals with depression must be allocating processing capacity to their own concerns since they put *less* cognitive effort into task performance.

A possible critique of the Processing-Efficiency Theory is that it has been formulated on the basis of experiments conducted with adult participants. Therefore, any generalization of the effects of stress on children must be considered in light of known developmental changes in working memory. Swanson (1999) demonstrated that age-related differences in working memory are related to storage capacity. For both visuospatial and verbal information, working memory capacity steadily increases from childhood to approximately 45 years of age, and then steadily declines. The Processing-Efficiency Theory would then predict that the impact of stress on working memory would be greatest during the early elementary years and somewhat improve with developmental increase in working memory capacity. However, the prevalence of worry appears to increase with age and cognitive development in childhood (Muris, Merckelbach, Meesters, & van den Brand, 2002). This would then suggest that increases in working memory capacity during the early elementary years might not ameliorate the impact of stress as the occurrence of worry increases also. Given these considerations, further research is needed regarding stress and developmental changes in working memory across the lifespan.

Another potential criticism of the Processing-Efficiency Theory is its reliance on Baddeley's conceptualization of working memory. A weakness of his theory is that the central executive is the component that he addressed the least in his empirical research and, as a result, is under-specified as to the processes and resources that are being used in working memory (Just & Carpenter, 1992). Although Elliman et al. (1997) roughly speculate as to how anxiety affects the central executive, the Processing-Efficiency Theory appears to be underdeveloped in respect to the architecture and constraints that are involved in the allocation and scheduling of working memory resources when anxiety is present.

This potential weak spot in the Processing-Efficiency Theory may open the door for capacity theories in the area of stress and memory as connectionist simulations are relatively explicit as to the set of processes and resources that are involved in working memory (e.g., Ericsson & Kintsch, 1995; Just & Carpenter, 1992). Furthermore, general capacity models imply that there is an effort dimension to thought in addition to correctness and speed (Just & Carpenter, 1992) — all central themes to how anxiety affects task performance (i.e., processing efficiency and effectiveness). It is likely that capacity models and their network simulations would conceptualize worrying as an extrinsic memory load that consumes the amount of resources available to a task. Worrying would then slow down the system because, as Just and Varma (2002) point out, as working memory capacity decreases, completion time increases and processing speed decreases. It is uncertain how capacity theory would account for the effects of worry on verbal tasks and not visuospatial tasks since — to the best of this author's knowledge —capacity theory has yet to be examined in cognitive domains other than language. Just and Carpenter (1992) suggest that it is likely that there is a large set of processing resources and there may be different subsets of resources used for different tasks. If this is the case, worrying may consume the subset of resources that verbal processing utilizes rather than visual processing resources.

Support for several of these assumptions come from Klein and Boals (2001) as they interpreted the effects of life stress on working memory using a limited capacity model. They found that participants with more life stress performed more poorly on a working memory task and that self-reports of intrusive and avoidant thinking predicted functional working memory capacity. Consequently, Klein and Boals proposed that cognitive representations of stressful life events compete with task demands for working memory resources. However, they did not attempt to simulate their findings using a computational model and there were several limitations to their study (e.g., they could not conclude a causal relationship between working memory span and life stress).

Neural network simulations are also in a unique position to model what might be happening in the human brain

during the stress response. Hart (1983) suggests that the brain undergoes "downshifting" where lower brain centers hijack resources from the cerebral cortex and put it to work protecting our body. Capacity theories and their connectionist simulations have potential in the study of stress, working memory, and the brain, but further research is required that interprets findings using this model.

In concluding this section, anxiety and stress are closely related and there is a significant body of research linking both to impaired performance in working memory tasks. The Processing-Efficiency Theory is perhaps the theory at the forefront of explaining how emotion and cognition interact. This theory describes how appraisals of threats, or worries, affect the working memory system and thus influence task efficiency: both phonological loop capacity and central executive resource utilization become impaired. Applicability to students in the classroom environment will follow the forthcoming discussion on long-term memory and stress.

The Relationship Between Psychological Stress and Impaired Long-Term Memory

The difference between working memory and long-term memory is clear from the names: working memory serves cognitive activities of the moment, while long-term memory is the permanent repository for knowledge already acquired. This is not to say that long-term memory and working memory do not interact. Long-term memory contains libraries of knowledge and skill that are recruited by working memory to interpret and act upon incoming and buffered information. These libraries can involve both episodic memory (autobiographical events) and semantic memory (conceptual and factual knowledge).

Both semantic and episodic knowledge appear to be activated and stored through involvement with the hippocampus, a ridge in the floor of each lateral ventricle of the brain that consists mainly of gray matter. This is also called the temporal lobe memory system (Sprenger, 1999; LeDoux, 1996). This hippocampal gateway is the key to how psychological stress interferes with the conscious formation and retrieval of long-term memories. LeDoux (1996) suggests that stressful events can cause malfunctions in the hippocampus through steroids secreted during the physiological component of psychological stress.

When a threatening situation is perceived, the adrenal gland secretes a steroid hormone into the blood stream, which helps prepare the body for intense physical exercise. The control and release of adrenal steroids are responsibilities of the amygdala, an almond-shaped mass of gray matter in the anterior portion of the temporal lobe. When the amygdala detects danger in the environment or in our cognitions, it sends a message to the hypothalamus, which in turn sends messages to the pituitary gland. ACTH (adrenocorticotrophin) is released as a result. ACTH flows through the blood to the adrenal gland where it controls the release of a steroid hormone named cortisol. Cortisol has a major influence on the body once it is released. It binds to receptor sites of every major organ system as well as areas of the brain such as the hippocampus, amygdala, and prefrontal cortex (LeDoux, 1996).

The hippocampal steroid receptors are part of a feedback system that regulates how much cortisol is released (Lovallo, 1997). When hippocampal receptors detect cortisol, messages are sent to the pituitary and adrenal glands to slow down the release. Essentially, the hippocampus is responsible for reducing the release of cortisol and the amygdala increases it. Through these loops, the concentration of stress hormones is delicately matched to the demands of the threatening situation.

If psychological stress persists too long, the hippocampus begins to falter in its ability to control the release of cortisol. As a result, the amygdala is free to increase cortisol levels of the blood. Sustained high levels of cortisol can then cause irreversible cell degeneration in the hippocampus (LeDoux, 1996; see also Jensen, 1998; Mendl, 1999). When this happens, disruption to memory functioning occurs.

Evidence for the injurious effect of stress on the hippocampus has been investigated via human and animal studies. Psychological stress has been used as an explanation for marked hippocampal degeneration in subordinate baboons in their local social hierarchies (Sapolsky, 1990), tree shrews with similar social hierarchies (Magarinos, McEwen, Flugge, & Fuchs, 1996), veterans with combat-related post-traumatic stress disorder (Bremner, Randall, Scott et al, 1995), and victims of repeated child abuse (Bremner, Randall, Vermetten et al, 1997).

A link between high levels of stress or adrenal steroids and the degradation in either the formation or retrieval of declarative memories can be found in several populations. Patients with Cushing's disease, a disorder where tumors on the adrenal gland cause excess cortisol to be secreted (Sapolsky, 1998), as well as patients with clinical depression (Sternberg & Jarvik, 1976), have displayed memory dysfunction. Individuals living with Alzheimer's may also be implicated as studies have started to link cortisol levels to accelerated brain aging and memory loss, especially hippocampal atrophy (Lupien et al, 1998; Porter & Landfield, 1998). Findings with these diverse populations support a link between psychological stress and long-term memory dysfunction.

To summarize this section, there appears to be compelling evidence that psychological stress can potentially impair the storage and retrieval of long-term memories. Cortisol, a hormone that is part of the flight or fight response, can cause damage to the neurological "gatekeeper" of declarative memories, the hippocampus. Brain pathology research in the area of stress physiology in both animals and humans supports this claim. In addition, populations that experience chronic stress and high cortisol levels appear to suffer from memory deficits as well.

The Relationship Between Impaired Memory and Language Processing

A relationship between impaired memory, both immediate and long-term, and psychological stress has been established and bits of relevant research have been discussed in the previous section. The relevance of this evidence to speech-language pathology lies in the well-established relationship between impaired memory and language processing.

The term "language processing" is often understood to refer to language comprehension, but language processing actually encompasses both receptive and expressive language. According to Richards (2001), Vygotsky (1962) was one of the first to apply the term *process* to language. For him, language processing was "a continuous back-and-forth movement from thought to word and from word to thought" (Richards, 2001, p. 7). This definition fits well with the scope of this paper as psychological stress has the potential to disrupt both language input and output.

Evidence for the claim that working memory is important in the reception of language can be found in studies showing that subjects with relatively small working memory spans are worse at language comprehension than subjects with relatively larger spans (Daneman & Carpenter, 1983). Similarly, in a study of adult readers, King and Just (1991) found that college students with low working memory capacity demonstrated poorer syntactic processing abilities than higher capacity students. Interestingly, Bar-Shalom, Crain and Shank-Weiler (1993) have argued that low working memory is responsible for the syntactic comprehension problems of school-age children with reading problems. Decrements in working memory capacity are also associated with poor auditory sentence comprehension in brain-injured adults (e.g., Baddeley, Vallar, & Wilson, 1987). These studies have shown that deficits in working memory can affect the accurate transmission of words to thought or the receptive processing of language.

One way to understand the relationship between long-term memory and language production processes is to consider the concepts of consolidation and access. Consolidation is the process of placing material in long-term memory and access is the process by which one finds information or skill in long-term memory (Levine, 1994). The crucial dependent relationship between consolidation and access is this: the more systematic a person is during consolidation, the easier it will be later to access or recall what one needs from memory (Levine, 1994). The most effective consolidation occurs when a person connects what he or she is learning to related material stored in long-term memory. That is, he or she tries to organize the new to-be-remembered knowledge into pre-existing knowledge. This in turn facilitates quick and efficient retrieval of the knowledge. An analogy of this would be a sock drawer. If you were looking for a certain pair of socks, it would take less time to find them if your sock drawer was organized rather than messy. In fact, finding your socks would be more efficient (less effort and less time) if you placed them in a pre-existing order. Likewise, accessing or recalling material in long-term memory would be more efficient if knowledge was organized and if incoming facts are placed in this pre-existing organization.

Incomplete processing or consolidation of incoming novel words is in fact a leading reason for word-finding difficulties in students (Smith, 1998). Kail and Leonard (1986) demonstrated that children with word finding difficulties did have the words they were trying to retrieve present in their lexicon. However, their retrieval was less efficient because they had associated less elaborate knowledge with these words during consolidation. They also knew fewer synonyms, related ideas, category members, and multiple meanings of the same word. Therefore, even though they knew the words, the meanings of the words were less distinct in long-term memory. In short, access to the phonological form of a word for language expression may be defective due to ineffective consolidation of a word in long-term memory to begin with –conversion from thought to word is sluggish.

Just as with semantic information, the consolidation and access of permanent episodic information are mutually dependent on each other. For example, in narratives, the intent is to convey the movement of events. This is usually expressed as a temporal sequence. If narrative consolidation in long-term memory is compromised this will have consequences for a student's ability to access and convey the movement of events accurately. Furthermore, exact knowledge of frequently recurring episodes or scripts facilitates the retelling of other similar experiences. Script knowledge can provide an organized framework to guide consolidation and retrieval of memories of specific events in order to aid accurate and elaborate retelling (Naremore, 1997). Again, if the consolidation is compromised, narrative access will suffer.

The Proposed Relationship between Psychological Stress and Impaired Language Processing

At this point it is important to summarize the evidence for a language-stress relationship: If stress negatively affects memory, and poor memory affects language processing, then stress affects language processing. This syllogistic reasoning gives us the indirect relationship between language and stress that we are attempting to find. Specifically, worries associated with psychological stress affect working memory as laid out by the Processing-Efficiency Theory and stress hormones disrupt the consolidation and access of long-term memories through the dynamics of the hippocampal system. Both of these effects in turn degrade language processing.

There have apparently been no studies that attempt to directly relate stress to specific language skills or difficulties (e.g., word-finding). Prevalence studies that note co-occurring emotional problems and language problems

are our current best source of evidence tying language processing to emotional health. These studies reveal a substantial overlap among language dysfunction and emotional/behavioural issues. After reviewing several studies in this area, Gallagher (1999) mentions that 62-95 % of children being treated for emotional and behavioural problems have co-occurring moderate to severe language problems. The language problems noted have included deficits in vocabulary, comprehension, expression and pragmatics. Similarly, studies looking at children with language impairment have reported emotional and behavioural problems in 50-75% of that population (Gallagher, 1999). In sum, it can be said:

> Even the lowest estimates have indicated that the probability of co-occurrence of emotional/ behavioural, and language problems in children is several times higher than would be expected if co-occurrence were simply due to chance. After a decade of research, it is now predictable that children identified with one of these problems has a higher than average probability of having the other problem as concomitant if not contributing factors to difficulties in their overall functioning (Gallagher, 1999, pp. 2-3).

While stress may indeed impair language processing, an alternative explanation is that students with poor language skills experience more life stress because they lack the ability to communicate and process information effectively, thus causing more stress in their lives. However, stress-induced situations in laboratory situations on normal populations have shown to negatively impact the accurate recollection of words presented on a list (Payne, Nadel, Allen, Thomas, & Jacobs, 2002). In fact, Payne et al. (2002) suggest that experimentally induced stress can affect memory possibly through its impact on the hippocampus and prefrontal cortex — the area of the brain where working memory is thought to reside (e.g., Curtis & D'Esposito, 2003). Given that experimentally induced stress can cause information processing interference, future research demonstrating a causative link between life stress and language processing should be fruitful.

Implications for Speech-Language Pathology in the School Setting

School-based speech-language pathologists should be aware of psychological stress as a contributor to learning difficulties. This is an important factor to keep in mind not only when considering how a student processes information in class, but also during assessment and intervention sessions. This section touches upon the implications of psychological stress on assessment and intervention issues, as well as suggestions for future directions.

During the assessment process, a clinician wants to obtain a sense of the student's information processing characteristics. Details to this end are gathered through in-class observations, parent/teacher interviews, reviews of previous assessments (e.g., psychoeducational), as well as formal and informal testing procedures. For a student who appears to be stressed, behavioural characteristics are indispensable in determining the locus of language processing breakdown. A student undergoing a rough emotional climate at home may present as a slow information processor when dealing with verbal and written material (i.e., processing efficiency); teachers may report that the student's "mind is somewhere else" or preoccupied with worries; the student may also be described as one who has problems remembering facts and is slow at mastering new material; word-finding difficulties and poorly developed narratives may also be evident (see Hart, 1983 and Jensen, 1998 for discussions of physical and behavioural characteristics of students who may be experiencing stress).

Speech-language pathologists assessing students dealing with emotional problems should also take advantage of formalized testing procedures. Assessment instruments that are sensitive to working memory and long-term memory would be ideal. Tests that include auditory memory subtests such as following directions, listening to paragraphs, recalling word lists, and/or recalling sentences verbatim are taxing to the working memory system. Suggested tests that include such tasks are the Wide Range Assessment of Memory and Learning (Sheslow & Adams, 1990), the Clinical Evaluation of Language Fundamentals-Third Edition (Semel, Wiig, & Secord, 1995) and the Test of Auditory Perceptual Skills-Revised (Gardner, 1996). To evaluate long-term memory functioning, the Clinical Evaluation of Language Fundamentals-Third Edition includes two fairly good supplemental subtests (the Rapid Automatic Naming and Word Associations subtests), but the widely available Word Test Elementary-Revised (Huising, Barrett, Zachman, Blagden, & Orman, 1990) is especially sensitive to the organization of semantic long-term memory. These measures can be used to explore the possibility that the stressed student is experiencing working and long-term memory dysfunction.

While formalized testing has many advantages, speech-language pathologists should consider the possible effects of stress on a student's assessment scores. That is, are the scores obtained through language testing a true reflection of linguistic competencies, or are they a partial manifestation of the student's emotional functioning at the time of testing? With this caveat in mind, speech-language pathologists need to investigate a student's home life as part of the assessment process in order to accurately interpret standardized scoring and form accurate diagnoses.

As a final implication, students experiencing emotional disorders such as anxiety or depression should be monitored for language dysfunction. This is especially important given that language disorders are more prevalent in children with emotional/behavioural problems. Psychiatrists, school counselors, speech-language pathologists, and teachers should work together in monitoring and/or screening these students for language impairments.

Perhaps the most effective role for a speech-language pathologist working with stressed students is as a

collaborator/consultant with the classroom teacher. The work on Processing-Efficiency Theory points to several areas in which we could advise teachers. For example, if worries occupy the phonological loop, the teacher might want to utilize visual support in class instructions. Further, if stress leads to increased processing time and decreased phonological loop capacity, the classroom teacher might want to compensate for these limitations by, for example, giving longer test times, or assigning reports in lieu of tests. Levine (1994) provides a number of recommendations for teachers and parents on managing problems with short-term and working memory in his chapter "Phenomena Related to Reduced Remembering."

A direct treatment role for the speech-language pathologist is available in remediating semantic disorganization and word-retrieval difficulties. The apparent answer here is to select intervention programs that focus on organizing the semantic system of the learner. A remarkably appropriate suggestion by Levine (1994) is the use of graphic organizers to help students develop an understanding of semantic networks and concepts (i.e., "word maps" and "conceptual maps"). These diagrams delineate the critical features, provide examples, and reveal the relationships of concepts and words. These could prove effective given that the visuospatial buffer of working memory is theoretically free from worries, and may shift attention away from these worries in the phonological buffer. Once more, the reader is encouraged to view Levine (1994) for examples of graphic organizers and other suggestions on "managing incomplete concept formation" and "weak language processing" at home and at school.

The intervention issues surrounding psychological stress and language processing are admittedly less straightforward than the assessment issues. There is as yet no evidence that language-processing problems spontaneously improve if service delivery programs address children's emotional functioning (Gallagher, 1999), although this prediction seems reasonable. And of course, treatment of the emotional and social problems underlying stress would fall to the mental health professionals and counselors employed by the school district and/or family. Even here, though, the speech-language pathologist could monitor language-processing performance while the student undergoes emotional health services and contribute this information as a member of an educational team.

Conclusions

This review clearly indicates the need for research that explicitly relates language processing and psychological stress. The path that was taken here was one of logic, not one of empirical science. In addition, much of the research carried out with anxiety and depression has been in the field of psychology, with the focus being on memory rather than language processing. Now it is the job of researchers in speech-language pathology and other areas of applied psycholinguistics to delineate the links between language processing and psychological stress. This new research area should deal with both language comprehension and language production processes. There is every reason to expect that this research will be fruitful given that many memory experiments dealing with working memory have used language-based stimuli such as sentences and passages. Work on problems with memory access and word retrieval may be more challenging since there does not yet seem to be any research that considers stress-induced hippocampal damage as a factor in individuals with chronic word-finding difficulties of any age, let alone students. And finally, we would some day hope to be able to explain how stress influences language development, or learning the language forms in the first place. Our continuing challenge as clinicians will be to ensure that as research addresses these issues, we create the appropriate assessment and intervention practices.

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