Retention of Cardiopulmonary Resuscitation Skills

Innovations in Research and Applications Especially Among Adolescents

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Executive Summary

The Advanced Coronary Treatment (ACT) Foundation of Canada is a national, award-winning charitable foundation with a mission to promote health and empower Canadians to save lives (http://www.actfoundation.ca/). ACT is establishing the lifesaving CPR program in high schools across Canada as a mandatory program. Schools commit to offering the CPR program at a grade level and in a subject area that will reach all youth prior to graduation. The ACT Foundation finds community partners to donate the start-up resources (mannequins, teacher training and materials) that schools need to deliver the program to all students. ACT also guides schools in program set-up. Since the inception of its original pilot in Ottawa in 1994, the ACT Foundation has set up the CPR program in over 1,500 high schools across the country. It is now a mandatory part of the curriculum in three provinces: Ontario, Alberta and Manitoba. One million (1,000,000) youth have been trained in CPR to date by their teachers through the ACT High School CPR Program.

This report is a review of the literature focusing on the retention of CPR skills especially among adolescents and aimed at providing the ACT Foundation with a critical understanding of those factors that may enhance the retention of CPR knowledge. This report was made possible by a grant provided by The J.W. McConnell Family Foundation.

Past research measuring retention of CPR skills has demonstrated generally poor retention among health professionals and lay people alike. However, it is important to note that most research on the retention of traditional CPR training in lay people is misleading for several reasons. First, the research methodology tends to be flawed resulting in poorer recall than might be expected if the research were designed more appropriately. Second, most research has included the application of a pulse check that has been found to be unreliable because people tend to have difficulty reliably distinguishing between the presence and the absence of a pulse. When this check is removed, studies show improved retention of the CPR sequence on follow-up. Current

trends in CPR research and applications have had significant success in incorporating scientific research on learning and memory from the cognitive, motivational and social psychological fields in order to design more optimal teaching strategies suited to the specific needs of different types of learners. More current research is showing that with better research designs and optimal teaching strategies, the retention of CPR has improved. For a skill such as CPR, however, retention should not be the only outcome measure of interest. The impact of CPR training can affect attitudes, values and beliefs that when learned in adolescence can be carried forward to future generations.

Adolescents play a particularly important role in the chain of survival because most cardiac arrests take place in the home. Their training as part of the high school curriculum provides a unique opportunity to dramatically increase the base skill-level of CPR in lay people so that death or neurological impairment from cardiac arrest can be significantly reduced. In attempting to improve the effectiveness of CPR training and to assess the value of new teaching methodologies for high school students, it is useful to take into consideration the following well-established principles from the research literature on cognitive, motivational and social psychology:

- Matching the learning process/sequencing of CPR actions/information to the way in which actions/information will be used in the real-life situation i.e. focus on procedural learning
- Removal of any actions/information during the learning phase not directly related to the target actions/information that needs to be acquired. This will help increase the salience of the target behaviours/knowledge
- Increase the strength of the association of each step with the next one. Support this by providing memory cues (mnemonics)
- Incorporate key CPR concepts into procedural learning rather than describe them
- Make actions/information in the CPR sequence easy to learn
- Keep only the essential steps in order to keep the number of steps at a minimum

- Support the association of specific action/knowledge sequences with specific external situational cues. Sequences will be held in long-term memory and automatically recalled when the appropriate situation arises
- Focus learning methodology on copying and practicing target behaviours. Practice is critical
- Visual modelling of skills to be learned – "Learn by doing what you see"
- Give students control over their own learning
- Teacher acting as facilitator rather than traditional lecturer to better support the student's learning
- Motivate students to learn by making the skill/knowledge a means to a personally meaningful end. Motivation is particularly important for adolescents
- Pair-up previously trained peers with a new student learner in order to increase motivation to learn
- Need for immediate and useful feedback to students provides an opportunity to reinforce actions/information and to correct. Adolescents have a thirst for learning. As a result, immediate and appropriate feedback is particularly important since failure to see progress will detrimentally impact an adolescent's motivation
- Deal with broader social-psychological reluctance to act in an emergency by incorporating realistic scenarios, role-playing, and personal responsibility. Train learners to bypass the natural diffusion of responsibility by interpreting and acting on an apparent emergency cue independently from how observers are behaving. Adolescents can be more easily influenced to control the bystander effect because of their susceptibility to peer pressure and their innate desire to meet goals that have high personal value
- Periodic short refreshers act by reinforcing long-term memory traces and their association with information about the emergency situation. It is better to provide a shorter and more effective initial training session and following up with a refresher later in the year in order to strengthen recall for CPR, than it is to have only one long training session during the year

- These refreshers could also provide opportunities to convey motivational information/activities. Activities might not necessarily be classroom-based, other than to describe the assignment. For example, an activity could involve searching the web to answer specific thought-provoking questions or summarize a true life-story related to a success or failure in the application of CPR. One potential option would be to encourage high school students to do volunteer work related to CPR/first aid

In reviewing current advances in CPR training, the experiential learning paradigm stands out as a useful framework for incorporating contemporary scientific principles of learning and memory into more effective teaching methodologies. From this paradigm, tools can be designed to optimize the acquisition, retention and effective real-life usage of CPR skills that are appropriate for one's role in the chain of survival. Although health professionals may greatly benefit from expensive almost life-like simulators, students focused on initiating the delivery of appropriate emergency procedures and basic life support as lay people are more likely to benefit from tools that are simpler, less expensive, yet still effective. In this respect, video-assisted learning stands out as the most promising for increasing performance of CPR among high school students. The above list of scientific principles is also useful because it provides a basis for assessing the value of proposed innovations to the teaching of CPR.

Introduction

Extensive research-based evidence supports the notion that lay people play a critical role in increasing survival from cardiac arrest since most incidents take place in the home. It is also clear that the CPR training of adolescents provides a key opportunity to develop an effective long-term training strategy for significantly reducing the impact of cardiac arrest in the home. The key challenge has been to improve CPR training to ensure the quality acquisition of skills, long-term retention of those skills and their effective use in real-life emergency situations. In the aftermath of numerous studies demonstrating the inadequacy of traditional CPR training, new directions in research and application have resulted in rich descriptions of the causal and supporting factors of good skill retention and recall. From these research efforts, new and improved teaching methodologies and tools have already significantly improved the effectiveness of CPR training. Of particular importance is the application of these tools to adolescents in high school settings as part of the standard curriculum. The current review examines the research on CPR training with a focus on retention and use in real-world emergencies. After examining CPR performance data related to traditional teaching methodology and the role of adolescents, key research findings on the cognitive, motivational and social psychological aspects of learning and memory that are key in the design of optimal CPR training programs are discussed. Finally, new CPR training developments are reviewed with respect to their applicability to adolescents in the high school setting.

The Evolution of CPR Training and the Key Role of Adolescents in the Chain of Survival

Precursor to CPR and the Birth of a Life-saving Technique

The earliest form of artificial respiration was described in the 1800's using *The Silvester Method*. According to this method, the victim is placed on her back, one inhalation-exhalation repetition is accomplished by raising the victim's arms above her

head to induce inhalation, and then, pushing on her chest to force exhalation. One repetition is performed every 3 – 4 seconds (Silvester, 1858). In 1911, the *Boy Scout Handbook* described a variation of the Silvester Method where the victim is placed on her stomach rather than her back (Boy Scouts of America, 1911). In 1957, *The ABC of Resuscitation* was written by the medical community in recognition of the importance of formalized training of CPR (De Vita, 2005; Grenvik & Schaefer, 2004). Formalized training became a reality with the advent of Resusci-Anne mannequins in 1961. In 1975, advanced cardiac life support (ACLS) training was developed (Nolan, 2001). By the 1970's, *The ABC of Resuscitation* was used to promote the training of lay people as key actors in increasing the chances of surviving cardiac arrest.

Over the past 30 years, two streams of influence have led to an increasing integration of CPR training into the everyday lay population. While CPR/AED training organizations such as the Red Cross, the American Heart Association, the Heart and Stroke Foundation of Canada and St John's Ambulance have provided training programmes for various target populations, other types of organizations have focused their efforts on devising strategies for integrating CPR and chain of survival training into the fabric of the lay person's everyday life. Of particular importance is the ACT Foundation's success at integrating CPR training into the high school curriculum in several provinces across Canada (www.actfoundation.ca). In so doing, the ACT Foundation has established a powerful mechanism for ensuring the effective and sustained provision of CPR and chain of survival services within the most affected segment of the population, the home environment.

EVOLUTION OF CPR GUIDELINES: INCREASING EFFECTIVENESS

Since the 1970's, guidelines for CPR training have changed several times. There is now a widespread acceptance that the training of lay persons and medical professionals must be different since their respective roles in the chain of survival differ. In recognition of this fact, the American Heart Association issued a supplement to their journal C*irculation*, in which they outlined changes to the cardiopulmonary resuscitation technique (December, 2005). The new guidelines were agreed upon at the 2005

International Consensus Conference on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science (AHA, 2005a). The primary goal of these changes was to simplify CPR for lay rescuers and healthcare providers alike, and to maximize the potential for early resuscitation (AHA, 2005b). These changes were based on research that showed that lay rescuers were unable to detect a pulse in 40% of the cases, and falsely assumed there was a pulse when there was none in 10% of the cases (AHA, 2005c). Moreover, research also shows that no detrimental health effects occurred as a result of giving CPR when there was a pulse (Wik et al, 1994). As a result, the new CPR guidelines for lay persons focus on signs of circulation by checking for movement, colour and coughing when breaths are administered as the key indicator for commencing CPR chest compressions (Handley & Handley, 1998). In so doing, starting compressions as quickly as possible upon observing signs of an impending cardiac arrest leads to better chances of survival with little chance of serious impact from errors.

ROLE OF LAY PERSONS IN THE SURVIVAL OF CARDIAC ARREST

Chain of Survival

On average, less than 10% of people who receive CPR survive (Eisenberg & Safer, 1999; Kette, Sbrojavacca, & Rellini, 1998). After 10 to 15 minutes, extensive brain damage has probably already occurred, so it is critical to keep blood flowing through the brain until qualified medical personnel arrive and can administer Advanced Life Support (ALS). In 1974, the American Heart Association began to recognize the key role of lay people. Being the first at the scene of an incident, the lay person can recognize the warning signs of an impending cardiac arrest, call for emergency help and administer CPR until ALS can be administered (Moser & Gordon, 1974). The helping response by lay people was seen as the first critical step in initiating what was termed, the chain of survival (Master, Dack & Jaffe, 1941). In the subsequent decade, the central role of lay people in increasing survival rates and decreasing the likelihood of brain damage became a central focus of research and application (Newman, 1998). By calling emergency personnel and providing basic life support, lay people provide a key bridge to the provision of advanced life support by qualified health professionals (Newman, 1998).

Early recognition is essential because it increases the chances of intercepting an emergency when it is most manageable.

Impact of Lay Person CPR on Survival Rates

Extensive research from studies on survival rates and quality of life show that the presence of a bystander who initiates the chain of survival on the earliest signs of cardiac arrest and administers CPR improves the survival rate of victims of cardiac arrest, delays neurological damage, and increases the number of hospital discharges (Liberman et al., 2000; Stiell et al, 2003). In fact, no CPR results in the lowest survival rate (Cerebral Resuscitation Study Group, 1989). Bystander intervention has been found to increase survival rates at least fourfold by increasing the window of opportunity for effective emergency intervention by medical personnel (Cummings & Eisenberg, 1985; Cummings, Thompson, Hallstrom & Cobb, 1979). A review of 16 studies in the USA and Europe showed that early bystander CPR made a positive contribution to survival with odds ratios up to 11.5, meaning that recipients of CPR were 11.5 times *more likely* to survive a cardiac arrest (Cummins, Ornato, Thies & Pepe, 1991). Brison, Davidson, Dreyer, et al (1992) found that the chances of survival after out-of-hospital cardiac arrest increased by 10.8% with bystander CPR as opposed to only 3.4% when a firefighter or police officer started CPR. Wik, Kramer-Johansen, Myklebust et al (1994) found that hospital discharge rates after 'good' bystander CPR (23%) were significantly better than after 'no' or inadequate bystander CPR (6%). A comparison of cities with and without CPR training for lay people provides a telling story.

More recent studies have confirmed the positive impact that bystander CPR has on survival rates. For example, in cities where CPR training for lay people is actively promoted, e.g. Seattle, survival rates are about 45%. Cities with little training for lay people, e.g. Atlanta, have much lower survival rates averaging about 3% (McNally, Kellerman & Park, 2007). In a prospective observational study of medical emergencies involving cardiac arrest, Citerio et al (2002) found that bystander CPR lead to a survivor rate of about 15% compared to 5% of victims without CPR. A large-scale analysis was conducted of data from nearly 5,300 cardiac arrest victims covering the time span from

1995 to 2002, from four provincial health databases, including OPALS, the largest prospective database on cardiac arrest known worldwide (Vaillancourt & Stiell, 2004). Results indicated that bystander CPR administered to victims of cardiac arrest increased survival rates from a range of 4% to 9% without bystander CPR to a range of 13% to 16% with bystander CPR.

In a separate analysis of OPALS data, Stiell et al (2004) found that victims of cardiac arrest who had received bystander CPR were more than three times as likely to survive, than those that did not receive bystander CPR, even when advanced cardiac life support was administered. In a study of the quality of life of survivors of cardiac arrest in 20 different communities, Stiell et al (2003) found that survivors of cardiac arrest who had received bystander CPR at the time of the incident were twice as likely as survivors without bystander CPR to have a very good quality of life one year after the incident. Quality of life was measured using a standardized interview instrument that assesses eight dimensions of health including vision, hearing, speech, mobility, dexterity, emotion, cognition and pain. The measurement method for these dimensions was based on extensive research from the decision-making literature in cognitive psychology. The instrument has been shown to have high reliability and validity in several populations (see Stiell et al, 2003).

In addition, research suggests that administering CPR incorrectly does not result in corollary health damage to victims. For example, Van Hoeyweghen, Bossaert, Mullie et al (1993) found that poorly performed CPR by bystanders had no negative health effects compared to cases which had not received CPR at all. Unfortunately, most victims of cardiac arrest do not receive CPR, and, as a result, most people who would otherwise survive cardiac arrest, die or experience brain damage while waiting for advanced life support (Becker, Ostrander, Barrett, & Kondos, 1991; Eisenberg, Horwood, Cummins et al, 1990).

KEY ROLE OF ADOLESCENTS IN THE CHAIN OF SURVIVAL

The place of Adolescents in the Chain of Survival

Studies suggest that between 75% and 85% of cardiac arrests take place in the home (Becker, Ostrander, Barrett, & Kondos, 1991; Eisenberg, Horwood, Cummins, et al, 1990; Gallagher, Lombardi & Gennis, 1995; Litwin, Eisenberg, Hallstrom & Cummins, 1987; Lombardi, Gallagher, & Gennis, 1994; Vaillancourt & Stiell, 2004). Approximately 50% of those suffering from cardiac arrest die before reaching a hospital (Christenson, Solimano, Williams, et al, 1993). Although this speaks to the importance of training family members in CPR skills, the initial question of devising a strategy for increasing the CPR skill-level in that cross-section of society was a complex one. Older adults were the most likely to witness a cardiac arrest (Goldberg, Gore, Love et al, 1984) and most of the people who took CPR training at the time were in their twenties and thirties and did so as an extra-curricular activity. The volunteer nature of CPR training, its cost, as well as time constraints and inconvenience made it difficult to substantially increase the training rate (Brennan, 1989; Brennan, 1991; Brennan & Braslow, 1998; Pane, 1987).

Early studies demonstrated that students could effectively learn, remember and apply CPR skills. It became apparent that incorporating CPR training into the school curriculum would provide the most efficient and effective means of increasing the presence of CPR skills in the home (Liberman et al, 2000). Mandatory teaching of CPR to high school students not only ensures a high percentage of trained people that can tend to cardiac victims in the home, it also promotes continuity of the motivation to learn CPR into the next generation. As adolescents age they will eventually carry into their home environment not only life-saving skills, but also the motivation to promote CPR training to their family members and friends (Cummins, Ornato et al, 1991). Training adolescents also improves the skill base of lay people in general and, therefore, the chances that a bystander will be able to assist a person suffering from cardiac arrest in public (Brennan & Braslow, 1998). As a long-term strategy, teaching CPR in schools addresses several issues: (1) need to train a large percentage of the population most at risk; (2) sustains the

training rate in the long-run; (3) trains individuals that have a high probability of influencing others to take CPR; (4) has a high return for investment because the funds provided are spent directly on training of people who will impact the target cross-section of society most at risk of death and brain damage from cardiac arrest (Cummings, Ornato et al, 1991). CPR training in schools has become a common practice over the last decade. For example, CPR is taught to students in England and the UK (Frederick, Bixby, Orzel et al, 2002), in Italy (Rosafio, Cichella, Vetrugno et al, 2001), in Canada and in the United States (Liberman et al, 2000).

Research on CPR Among Children and Adolescents

Research into the acquisition, retention and use of CPR skills by children and adolescents has been receiving increasing attention in the past decade. The following studies demonstrate the viability of training students to be effective members of the chain of survival.

1. **UK and Europe**

Frederick et al (2002) studied the retention of sequencing and assessment skills of Basic Life Support (BLS) at a 5 month follow-up in 1,292 students, aged 10 – 11, in the UK and Europe after initial training using The Injury Minimization Programme for Schools (IMPS). This study also investigated the impact of simplifying the requirements for correct CPR by removing the need to determine the presence of a pulse. Half of the students received CPR training (I: intervention group) and half did not (C: control group). Training took 1 hour and 10 minutes, was taught using the 1997 Guidelines from the European Resuscitation Council, and included a combination of traditional teaching and experiential learning. Just over half the time was spent on teaching sequence and skills. They used a mnemonic 123ABC as a jingle to help learning and memory. About 43% of the session was spent practicing on mannequins and role-playing. There were two trainers per class and for an average of 14 children per class (ratio impacts the trainer's ability to monitor, correct errors and reinforce what is being done right). Children were tested with small portable mannequins only once at follow-up. It was felt that a pre-test at the onset of the study would have contaminated the results and that it would have been unethical to

test the controls at pre-test without then showing them the correct procedure. Children were tested without warning to prevent uncontrolled revision.

A number of key results emerged. At 5-month follow-up, the intervention group was significantly better than the controls in almost all areas of BLS suggesting significant retention. There was a large increase in the percentage of correct CPR sequences for the intervention group but not the controls, when the carotid check was not required (24% versus 2%). The use of strict guidelines resulted in equivalent results for intervention and controls (1% versus 0%) suggesting that inclusion of the carotid check in research studies leads to results that misleadingly suggest dismal retention of CPR skills. The Resuscitation Council (Handley & Handley, 1998) has suggested moving away from carotid check as a sign of cardiac arrest, towards signs of circulation by checking for movement, colour and coughing when breaths are administered.

One threat to reliability, however, comes from the fact that assessors were not blind to intervention versus control participants. As a result, their assessment of skill level at follow-up could have been impacted by bias. In addition, the lack of a test at training time for the Intervention group precludes a determination of actual retention since there is no baseline against which to compare follow-up performance. This criticism is mitigated by the fact there was a control group. A control group can reasonably be interpreted as the performance level one would have had if one had completely forgotten initial training.

The current results suggest that the previous emphasis on carotid check resulted in an underestimation of truly useful BLS administrations. The simplification of the process may also lead to improved acquisition and retention of the procedure as suggested by research. For example, adults find the full 8-step process difficult to learn and hard to remember (Chamberlain & Hazinski, 2005; Moser, 1992). Handler and Handler (1998) recommended that the sequence be reduced to four steps and that material in general be revised and simplified to improve acquisition. From a cognitive perspective, the change in guidelines has resulted in an elimination of unnecessary information from the training methodology, thus supporting the learner in focusing attention on key skills.

The high skills and knowledge retention rates of children in this study speaks to the effectiveness of the BLS sequence and assessment. Of note is the increased emphasis on the practical application of skills that has become a focus in recent years (discussed later in this paper). Of note, is that children aged 10-11 acquire, retain and recall BLS sequence and skills when the process is simplified to focus on target skills. Replacing the pulse check with signs of circulation also makes the decision to administer CPR in the real life situation easier because it is less dependent on the identification of signs that are difficult to reliably assess, even for professionals. The demonstration in this study that BLS training can be significantly shorter (about 1 hour) than that previously thought, makes the incorporation of CPR into the school curriculum more feasible, and still results in significant retention of CPR skills over several months.

2. CEGEP in Quebec

Liberman et al (2000) conducted a study for the main purpose of making recommendations on the feasibility, efficacy and viability of implementing a CPR training program for students in the CEGEP system (junior college) in the province of Quebec. More generally, they were interested in making evidence-based statements about CPR training in high school students as a whole. The study was motivated by a growing belief in the research and teaching communities that training students in CPR would dramatically increase public awareness and interest in CPR, as well as the base skill level of CPR in the general population. More specifically, the study investigated the effectiveness of different course designs and teaching methodologies in order to illuminate one of the key concerns of the day, i.e. how to optimize retention of CPR skills in an efficient manner. "The hypothesis tested was that shorter and non-traditional methods of BLS CPR instruction could be equal to or better than the traditional, 4-h Heart Saver course, which is currently being taught at a sub-optimal rate to the public throughout North America" (Liberman et al, 2000).

CEGEP students were randomly assigned to one of four conditions, each representing a different combination of class length, type of instruction and amount of

practice. Here is a simplified description of the study's design. The control group was given the standard 4-hour course with the instruction and practice component as recommended by the Heart and Stroke Foundation of Canada. One comparison group was given a two-hour training session that consisted of practice only with no lessons. A second comparison group was given an 11-minute CPR video. Students were allowed to watch and practice with the video for as long, and as often as they wished, but without a teacher i.e. no instructions or feedback. This second comparison group used cardboard mannequins and were allowed to take their mannequins and videos home and practice at their leisure. The other group used standard mannequins.

Students were tested on two occasions, once right after training at the beginning of the semester, and then again at the end of semester (17 weeks later) using a computerized mannequin (Laerdal Skillmeter Resusci Anne). The mannequin was programmed to exhibit a specific sequence of realistic behaviours e.g. initial breathlessness followed by a pulse in both carotids after CPR. Test sessions were videotaped in order to analyze the sequence and reasons for test errors. All three groups performed equally well in the rate of correct compressions and ventilations at initial and follow-up test sessions. Although the video and practice-only groups did better than the traditional group at using the ABC sequence at initial testing, by the end of the semester all groups faired equally well. These results suggest that using video-based CPR learning and a cardboard mannequin without instructor results in acquisition and retention of CPR skills over a 17 week period that are comparable to that obtained through the conventional 4-hr Heart Saver course or the 2-hr version of the Heart Saver program with practice component only. One criticism of this study is that it did not control for practice during the delay between the two testing sessions. Replication of these results with larger sample sizes would also help confirm whether the different teaching methodologies have equivalent impacts.

This study provides evidence that students can effectively learn and retain CPR skills and that the video/cardboard-mannequin method may provide a cost-effective means of teaching CPR to students. The authors make the case that in 1997, 33,245 persons were certified or recertified in 'Heart Saver' CPR in Quebec. If CPR training was

to be implemented in all CEGEPs, over seven times the number of people would be certified in CPR each year in Quebec, increasing the number of trained lay persons in Quebec from 33,000 to nearly 300,000.

3. Comparison of Adolescents and Police

Rosafio, Cichella, Vetrugno et al (2001) compared 209 law enforcement officers and 393 high school students, aged 17-18 years old, on the acquisition and retention of BLS steps and CPR skills. All participants were initially trained until they passed AHA guidelines using the standard AHA program i.e. 2 hours of theory followed by 2 hours of practice on a mannequin. Retention of the ABC sequence and CPR steps were assessed two months after training using a questionnaire. There was no assessment of actual skills. Over two thirds of the participants responded to the questionnaire. Results indicated that students were significantly better at recalling steps correctly (18% versus 4%). These results parallel a previous study of real-world cardiac incidents (Brison, Davidson, Dreyer, et al, 1992) that found that the chances of survival after out-of-hospital cardiac arrest increased by 10.8% with bystander CPR as opposed to only 3.4% when a firefighter or police officer started CPR. These results indicate that students are able to learn and retain information about the correct CPR sequence. The value of using a survey assessment lays in the ability to evaluate information recall about the CPR sequence in a large sample size. In this case about 400 of the original 600 people initially trained responded to the survey.

A future study could enhance these findings by matching the evaluation method to the method of learning i.e. assess participants while they are performing CPR. As will be discussed later in the section on Learning and Memory, recall for a procedural task is better when the context of the test session matches the context of the learning session. Having said this, survey and experimental methodologies are both important because they provide complimentary information. The former provides a better understanding of the generality of CPR retention in the population of interest, while the latter provides a deeper understanding of how the populations differ.

4. Undergraduate Students

Ward et al (1997) conducted a study with undergraduate students in order to create a simplified checklist for lay persons to use in emergency situations. A short checklist and a long checklist were used as part of a test for acquisition right after training and then again for retention two months later. There was also a control group with no checklist. Participants were tested on actual CPR skills using a computerized mannequin. All three groups performed equally well at training suggesting that training successfully resulted in equivalent acquisition of CPR skills. Equivalency of baseline performance is important methodological success because it allows for valid group comparisons at follow-up. At follow-up, the long checklist group did significantly better than either the short checklist or no checklist groups on all steps of the procedure suggesting that the complexity of the standard CPR sequence leads to rapid forgetting. There were no differences between the short checklist and the no checklist conditions. For example, 89% of the long checklist students remembered to call 911 compared to only 50% of either the short checklist or the no checklist conditions. Although there was no significant difference among the groups in the proportion of correct compressions and ventilations, the long checklist group did perform significantly better than the other groups on the compression to ventilation ratio (84% versus 62%, 70%). Although the authors conclude that the checklist would help improve performance of lay persons, an alternative and perhaps more useful conclusion is that the results point to the importance of simplifying the CPR instructions for students and lay persons in general. This issue has received considerable attention in recent years, and has resulted in a simplified process based on the finding that teaching methodologies can map to the role that learners play (lay versus expert) but still result in significant health benefits (AHA, 2005). This issue is discussed later in this paper.

5. Other Studies

Connolly, Toner, Connolly, & McCluskey (2007) administered CPR training tailored to 10-12 year old students and found significant retention even when tested 6-months after initial training. Kelley, Richman, and Ewy (2006) studied acquisition and retention of CPR and automated external defibrillator (AED) among students in Grade 8. They found that about 88% of students were proficient at initial training and 84% at

follow-up four weeks later. Mock adult cardiac arrest scenarios were used to test actual skill levels. Vanderschmidt (1975) showed that high school students could learn and retain the practical skills involved in CPR even after extended delays. Students were tested three months after training and, confirming other studies, showed little loss of memory for ventilation and compression skills, but poor retention for assessment procedure that precedes CPR i.e. open airway, vital signs. Even 15 months after the initial training the results paralleled exactly the results for the three month test (Vanderschmidt, 1976). However, of critical importance for teaching methodology, it was also found that variability in CPR performance was related to the skill level of their school teachers. As will be discussed later in this paper, modifying the standard CPR teaching methodology to ensure more consistent learning is a critical aspect of improving acquisition and retention.

In an exploration of age effects, Lester at al (1996) found that children as young as 11 years of age are capable of learning CPR; however deterioration in skill levels occurs rapidly for children that are 11 years of age. Recently, Jones, Whitfield, Colquhoun, et al (2007) provided a more detailed examination of age-related differences in the ability to learn CPR. They found that children aged 9 to 10 were able to perform compressions to the recommended guidelines, but only the 13 to 14 year olds performed as well as adults. The ability to apply the correct rate and hand position was the same regardless of age. Similarly, Van Kersschaver, et al. (1989) showed that BLS skills were performed better as the age of the adolescent increased.

POOR RETENTION OF CPR SKILLS

Thirty-five studies between 1975 and 1996 showed poor retention of compressions, ventilations and the sequencing of steps in lay persons trained in CPR suggesting that standard training practices are not optimal (Berden, 1994; Brennan & Braslow, 1995; Handley & Handley, 1998; Kalmthout, 1985; Kaye et al, 1991; Morgan et al, 1996; Nelson et al, 1984; Sefrin et al, 1994; Ward et al, 1997; Weaver, 1979; Wilson et al, 1983). In a large survey of lay people trained in CPR, Celenza, Gennat, O'Brien et al

(2002) found that number of times a person had been trained was a more important predictor of retention than time elapsed since training. Time lag since training varied from less than one year up to more than five years. Of particular relevance is the finding that theoretical knowledge was not a good predictor of retention. Impaired retention impacts the chain of survival both in terms of the ability to apply CPR, and more generally, in terms of initiating and maintaining the steps in the chain of survival necessary to ensure that the victim survives until professional emergency help arrives. Both skills are necessary for increasing survival rates and minimizing brain damage.

Kaye et al (1991) and Ward et al (1996) came to similar conclusions suggesting that poor retention is due to long lectures, inconsistent information by trainers and little practice time. Additionally, Brennen and Braslow (1995) found that (1) many basic errors were left uncorrected by trainers, (2) trainees did not provide feedback to each other, and, (3) trainees were massively overconfident compared to actual performance levels. Early attempts had previously been made to standardize the information presented to learners by using computers and videos (Kaye et al, 1993), modifications of the teaching methodology (Plank et al, 1989), and self-paced instructions (Friesen & Stotts, 1984). However, these efforts remained ineffective (Friesen & Stotts, 1984; Kaye, Montgomery, Hon et al, 1983; Plank & Steinke, 1989). The root cause of inadequacies in the teaching methodology and its impacts on acquisition and retention were not yet well understood. A more recent and thorough analysis of reasons for poor findings on retention of skills and knowledge (Braslow et al, 1997) identified 12 common problems with traditional CPR instruction for lay persons that followed the pre-2005 CPR guidelines. This analysis provided an important catalyst for the re-examination of teaching methodology. Issues included:

- Problems with traditional CPR instruction for lay persons
- Logistical obstacles associated with class room learning (e.g. travel time and inconvenience)
- Psychological barriers and distractions to learning in a classroom environment (e.g. learning and performance anxiety, unfamiliar setting)
- Mismatch of participants' expectations and actual course content

- Use of non-lay person (medical) terms and language during CPR instruction (e.g. airway, circulation)
- Significant delay between instruction of detailed skill sequences and opportunity for mannequin practice
- Limited time for mannequin practice
- Course content unrelated to performance of CPR
- Problems with skill performance and retention
- Lack of step-by-step direct instruction in mastering skills
- Problems with instructor competence
- Lack of meaningful supervision and feedback by instructors
- Fear of performance in a real situation due to skill complexity and presentation of unnecessary information

Until recently, most research on retention was based on the early traditional teaching methodology of the 1980s and the use of assessment tools that assume a higher level of expertise than lay people have. As will be discussed in this paper's section on Learning and Memory, the didactic approach to teaching results in sub-optimal performance for skills/knowledge that require a high degree of procedural steps. As a result, the poor retention of CPR skills reported in many studies is probably due in part to sub-optimal acquisition (Chamberlain et al, 2002). Moreover, the assessment standard in traditional CPR training was also higher than what is actually needed in order for lay people to provide significant value in an emergency situation. Many research studies began to recommend that the CPR procedure for lay people be simplified (Rosafio et al, 2001; Ward et al (1997). Others argued, however, that the CPR technique itself should not be simplified, but rather the course simplified by removing "gratuitous material unrelated to resuscitation" (Brennan, Braslow & Kaye, 2000). Still others point out that different skills are needed for different roles and that new training techniques must be developed to support optimal CPR administration in their context of use. This position refers specifically to the role of lay people in the chain of survival as the first observers of an impending cardiac arrest and initiators of the sequence of life support, in contrast to

the role of the emergency health professional who administers advanced life support (Chamberlain & Hazinski, 2003).

Brennan and Braslow (1998a) suggested that fixing the problem would require focusing on four areas: focus training on learner outcomes, identify learning needs and how to best meet them, improve knowledge transfer from classroom to real life, and do properly designed research studies that include valid outcome measures (Brennan and Braslow, 1998b; Brennan, Braslow, Batcheller, et al, 1996). Braslow and Brennan (1998) also point to the reluctance of bystanders to administer CPR, and that this may be due to lack of self-confidence about their ability to deal with an emergency effectively. In the next section, we review key cognitive, motivational and social psychological aspects of learning, memory and usage of learned skills in the real-world. The intent is to list key research-based dimensions to consider when designing a course in CPR, especially geared to adolescents, so that it results in optimal retention of CPR skills, and increased chances of being an effective link in the chain of survival. As we shall see in the last section of this paper, recent changes in CPR teaching methodology have already resulted in significant improvements.

The Cognitive Science of Learning and Memory: Protecting Skills Against Forgetting

NEUROSCIENCE VERSUS COGNITIVE SCIENCE

In a review of neuroscience and education, Bruer (1998) could have been speaking about the teaching of CPR to students when he stated that "the challenge for educators is to develop learning environments and practices that can exploit the brain's lifelong plasticity, define the behaviours we want to teach, design learning environments to impart them, and constantly test the educational efficacy of these environments." (p. 18). Although brain research provides general concepts that apply to education, the establishment of a link between the neuroscience of the brain and the behaviours targeted

for learning is not a direct one, and, as a result, presents challenges as a basis for informing teaching methodology. Although less trendy, cognitive science provides insights that are directly applicable to designing effective teaching methodologies.

There is a basic difference between neuroscience and cognitive science. The former is about the physical brain, including electro-chemical events, physiology and structure. The latter provides theories about intelligence, learning, memory and other aspects of human behaviour. In order to relate brain science to learning and memory, cognitive science theories would be required. Although currently very popular, neuroscience is difficult to relate to real-life skills because it lacks concrete theories of human information processing and behaviour. For example, although there is good evidence to suggest that various parts of the brain experience rapid growth during adolescence, it has not been possible to relate these findings in any useful way to innovations in teaching methodologies needed to achieve optimal results in learning and memory (Bruer, 1997). The most useful statement is that neuroscience points "to the brain's lifelong capacity to reshape itself in response to experience" and that this physiological fact forms the substrate for changes in learning and memory (Bruer, 1998, p. 18). From this perspective, the adolescent brain which undergoes rapid re-organization of connections established during pre-adolescence, is optimally set for learning and retaining new skills such as CPR. As a result of this paper's focus on the practical application of learning and memory to CPR retention and recall, neuroscience research will not be discussed further.

Cognitive science, on the other hand, provides many theories and models of learning and memory that can be more easily applied to teaching in concrete settings. However, an exhaustive review of these theories would not be useful for the purposes of this paper. Rather, this section will focus on key research-based concepts that can be most useful in improving CPR teaching methodology for adolescents and lay people in general. In the end, the test of effectiveness of CPR training is the ability to use these skills when needed in real-world situations. Contemporary shifts in cognitive science provide a richer understanding of what drives learning and memory than the traditional narrow focus by taking into account context of learning and context of use. This section will focus on

those aspects of the learning and memory literature that are most relevant to CPR training.

PHASES OF LEARNING AND MEMORY

Complex cognitive research on learning and memory can be simplified into three broad phases of information processing: encoding, storage and retrieval (Glass & Holyoak, 1986). The characteristics of these phases provide insight into various strategies that can be used to optimize their performance for everyday use. The development of teaching techniques that support optimal learning, retention and retrieval follow from this research.

The first phase, encoding, allows our nervous system to take external stimulus information captured through our senses, and organize it. For encoding to happen properly, we need useful resources to convey the information, time to study and practice the information to support consolidation, minimal distractions from the target information, grouping of information into manageable chunks, distinctive memory codes that allow recall at later stages, feedback to ensure that acquisition is accurate and optimal, deep processing for quality representations, sequencing that matches real-world needs, and preservation of meaningful context. All of this happens in short-term memory processing.

For this processing to work properly, one must be able to pay attention to the information. Attention is thought of as the glue that binds information together. Attention also brings into play other factors that are central to learning and memory since these direct the learner's focus. These include motivational and social psychological factors to which adolescents are particularly susceptible. Motivation plays an important role in promoting goal-oriented learning, a key driver in practicing efficiently and creating quality encoding of information so that it can be stored in long-term memory for later retrieval. Social psychological factors also impact the retrieval of information, such as CPR skills, by dictating our natural responses to events when other people are present.

The process of organizing and linking information in short-term memory (Atkinson-Shiffrin Theory, 1968) needs to create a rich memory representation that incorporates cognitive, motivational and social components necessary for efficiency and effective retrieval when needed.

With enough optimal practice, the encoded information and its associated context are transferred from short-term memory into the second phase i.e. storage in long-term memory for later retrieval. Many theories of long-term memory exist, but at its most fundamental, long-term memory stores whatever we practice in short-term memory. As we shall see, acquisition places the greatest constraint on the quality of retained information in long-term memory, and as a result, on what we recall when the stimulus situation arises. Attempts to change learned patterns of skills/information require a lot of effort and are not typically completely successful.

Memory is important because its long-term stored information can be retrieved and used when the need arises. In this third phase, short-term memory, also referred to as working memory, is where information from the present is combined with information stored in long-term memory to guide behaviour in an adaptive way. Key to successful retrieval is the use of good cues that were previously developed in short-term memory, and the quality of the long-term memory store that minimizes the need to use-up short-term memory processing. In other words, if something is well learned, all that is needed is the detection of the appropriate cue from one's environment and the correct sequence will be recalled from long-term memory. Efficient use of short-term memory by using good cues and ensuring maximal quality of longer-term memory storage helps ensure quick and reliable retrieval and usage. Finally, although a neglected area of research, memory must be examined in the real context in which it will be used. Traditional learning and memory research focuses on components of memory processing as if they were brain functions that chug along independently from reality. However, their true nature is far more complex than early research suggested. Of relevance to concerns with the retention of CPR skills is the current trend in learning and memory research to

incorporate the real-world context into the investigation of the factors that impact our ability to learn skills/knowledge and use them (Nairne, 2005).

HOW WE LEARN

Although there are many theories of learning and memory, the most basic principle in cognitive research is the difference between short-term and long-term memory. The focus on short-term memory is particularly important because it allows us to hold information, think through problems, learn new skills and perform various tasks. It is designed to build up these skills by temporarily storing multiple types of information, including a set of executive functions that play a key role in putting together sequences of thoughts and behaviours. These include, for example, phonological aspect of words, semantic meanings of words and objects, perceptual appearance of objects, and spatial representations of objects in space. Executive functions include things like focused attention, when to do what, inhibition of other responses, and retrieval from long-term memory (Jonides & Smith, 1997). Short-term memory is critical in acquiring new knowledge/skills and transferring them to long-term memory. Short-term memory is also the means by which we recall information and skills from long-term memory in order to use them in real-world contexts. Performance will be high to the extent that skills/knowledge have been well committed to long-term memory, and to the extent to which there are enough attentional resources to detect contextual cues, analyze them and correctly retrieve stored information/skills (Logan, 2005). Research shows that intellectual tasks use up a considerable amount of cognitive processing capacity, and interfere with the ability to focus attention and to sequence target behaviours so important in acquiring new skills/knowledge (Kellogg, 1994). This has two implications for the retention of CPR skills and their effective recall and use when needed.

First, CPR information should be simple and focused on acquiring the target skills with as few distractions as possible, especially unrelated tasks that require cognitive skills e.g. finding information in manuals, understanding theory, etc. Any unnecessary tasks will use up valuable short-term memory capacity and reduce the quality of the long-term

memory for the sequence. Second, sub-optimal storage of CPR skills/knowledge in long-term memory that is likely to result from the previous issue, will use up valuable short-term memory processing when recalled in an emergency situation in an attempt to "fill-in the blanks" for the degraded skill information. Moreover, low short-term memory resources will impact the retrieval of other skills/knowledge required to deal with the context of a real-world emergency. For example, recalling the other tasks that one should do as part of the chain of survival, and dealing with the motivational and social psychological aspects of the situation. As a person develops expertise i.e. commits the target skill to long-term memory, their use of short-term memory becomes highly efficient because the expert only needs to recognize appropriate cues for the appropriate response to be retrieved from long-term memory. This leaves the expert with more short-term memory resources needed to assess the broader situation, retrieve a range of appropriate behaviours and to adapt to the needs of the situation (Kellogg, Johnson & Rickard, 2005). This is highly relevant to dealing with a real-life situation involving cardiac arrest, where successfully dealing with the situation involves more than performing CPR correctly. This is especially important for adolescents whose major challenge may be the social pressures of an emergency situation.

Skill acquisition appears to happen suddenly in steps rather than increase in a continuous fashion (Kellogg et al, 2005). This sudden change indicates that a skill has moved from being a laborious short-term memory task to more of an automatic fast retrieval process from long-term memory. As a result, individuals who are able to transfer skill knowledge to long-term memory have a great advantage when required to recall this information. CPR teaching methodology should maximize the ability to shift skills from short-term memory to long-term memory. This means a teaching methodology that

- Minimizes any extra information that is not focused on skill acquisition
- Focuses on hands-on practice
- Creates a learning context that is similar to the home context within which students are most likely to have to recall CPR skills

THE IMPORTANCE OF CONTEXT

Most theories of learning and memory have spawned research focused on the acquisition and recall of intellectual knowledge based primarily on the task at hand. Although these cognitive models have significantly improved educational practice, their focus mainly on shorter-term issues has precluded a thorough investigation of the role of context on retention. This is understandable since contextual conditions that affect maintenance, recall and usage are difficult to manipulate experimentally, and are typically only observed in the long-run (Bahrick, 2005). Nonetheless, research studies are now converging to suggest that learning and memory is far more complex than previously suggested (Neisser, 1978). Context of learning and use is probably one of the most powerful factors that should be considered when developing teaching methodologies. In fact, performance for the same task can vary greatly depending on the context of use. Context includes not only the way in which one is required to execute a specific task, but also the physical environment in which learning and usage take place, the motivation for recalling and using the skills/knowledge, and the demands of the situation (Dick & Carey, 1990; Fiske, 2004).

As a very simple, but powerful, example of context-dependent recall, consider a study where individuals were required to memorize a list of 40 unrelated words, a typical research paradigm in memory research. However, learning and recall contexts were varied. One group learned the list on a beach. The other group learned the list 20 feet under water. Half of the beach group were then asked to recall as many words as possible while sitting on the beach, while the other half was tested under water. Half of the under-water group were tested under water, while the other half of the group was tested on the beach. Results show that words were recalled much more accurately (about 60% more) in the environment in which they were learned (Godden & Baddeley, 1975). Further research showed however, that a strategy could be used to improve performance when tested in a different environment. Specifically, participants were placed in a different environment, and, before being asked to recall the list, were asked to think about the original environment in which they learned the words. Amazingly, the context effect

disappeared. With visualization of the original learning environment, recall in the different environment was just as good as recall in the same environment (Smith, 1979).

One everyday example of a different aspect of context illustrates the importance of the mapping between how a skill was originally learned and how one is required to demonstrate that skill. "Cat's Cradle" is a game in which two people make patterns with string between their fingers and modify the pattern as they pass them back and forth. Only a slight mistake can result in a complete loss of the string pattern. A common observation is that despite the complexity of the patterns, the execution of Cat's Cradle is easily recalled even when individuals have not done it for many years. Although exhibiting difficulty in describing the steps (declarative information), people are often able to perform the complex manoeuvre intuitively (procedural information). This is an example of the importance of matching the way in which something is learned to the way in which it will be used in the real-world i.e. in order to perform a skill in the real world reliably and accurately, the training methodology has to focus on supporting an acquisition strategy that uses the same sequence executed under the same conditions using the same type of knowledge that applies to the context of use. It also points to the role that repetitive hand motions/physical contact has in creating deep learning of sequences of skills/knowledge (Goranson, 2001).

Sequence learning results from encoding a sequence of pieces of information where each item/action serves as a stimulus to activate its successor. Although sequence learning can occur without awareness (Hebb, 1961), in general, deliberate effort is required (Glass & Holyoak, 1986). This is accomplished through a generative procedure involving the deliberate repetition of a sequence in the same order. The extent to which an acquired sequence can be disrupted depends on the degree of learning, which in turn depends on several factors including number of items/actions, their complexity, the degree of natural association between items/actions, noise, context effects and motivation. Disruption of a well-learned sequence occurs when new items are incorporated into the sequence and break the learned associations. Since the generation of an automated sequence requires that each item/action be strongly associated with its

successor, any changes in the items/actions of a given sequence will disrupt the performance of the sequence. Items whose successors have changed will not function as stimuli for the next item/action until the old association has been broken and the new one created. The role of repetition in creating strong associations that are resistant to forgetting cannot be overemphasized (Briggs, 1957; McGeogh, 1936). Healy & Bourne (1995) extended the importance of sequential learning by showing that teaching methodology will be optimal when the learning context matches the context in which the information/skills will be used.

Skills are therefore domain and even task specific with the ability to recall relevant information tightly linked to the original learning context. Healy, Wohldmann & Bourne (2005) examined what is called the procedural reinstatement principle by exploring the relative importance of procedural and declarative information on three aspects of training that are key in ensuring that information/skills learned during training will be effectively recalled when required in real-world situations. Training "efficiency" refers to the use of training methodology that yields the best learning in the shortest and most cost-effective manner. "Durability" of learned information refers to the retention of skills so that they can be effectively applied when needed. And "transferability" is the extent to which learned skills/knowledge can be applied to situations that differ from those applied when training occurred.

Research on a wide variety of tasks, from pure knowledge recall to pure motor skills, support this principle which states that recall of skills/knowledge will be highest if the procedures encountered in a task match the procedures learned during training. In addition, data clearly show that the procedural component of a skill/knowledge is much more important than declarative information which is quickly forgotten. For example, individuals are often able to do something accurately but not necessarily able to describe the procedure (such as Cat's Cradle). Research has shown that this is the case for many skills whether knowledge-based like mathematics, or motor-based such as typing information into a software application, or a combination of the two such as driving a car (Marmy & Healy, 1995). This suggests that learning while observing and doing will lead

to much better retention than being taught using traditional didactic teaching where the procedure is explained. It also suggests that a hands-on approach to teaching will yield optimal results when the procedure being taught is as similar as possible in sequence and in context to what will occur in the real-world situation. Unfortunately, data also show that skills/knowledge learned in one context do not generalize well to different contexts.

Taken together these data provide important direction for CPR training. Specifically, the optimal teaching method for CPR skills is one that is focused on students learning while observing and doing rather than taught using the traditional didactic approach of describing the process. These research findings also suggest that the learn-while-doing approach should incorporate as many of the real-life scenarios as possible in order to minimize context effect mismatches between the learning and usage environments. This implies practicing with real-people as well as mannequins, and using settings that match real-life. This methodology requires quick, useful and timely feedback in order to correct errors and ensure that the correct sequence is acquired. As an example of the importance of good feedback while practicing, research shows that computerized learning systems can be successfully developed to maximize the acquisition of procedural and knowledge information (Graesser, Hu & McNamara, 2005). These data show that students learn more with a system that requires them to actively participate in the learning process rather than simply being presented with facts (Collins, Brown, & Newman, 1989). This research also suggests that the use of a properly designed computer system in conjunction with a facilitator leads to greatly enhanced learning and recall. In this methodology, the tutor first models a desired skill, and then the learners perform the skill while the tutor provides feedback and explanation. Finally the tutor fades from the process until the learners perform the skill all by themselves (Collins, Brown, & Newman, 1989; Palincsar & Brown, 1984; Sleeman & Brown, 1982). A computer system helps to provide consistent information to students as well as student-specific feedback. Such a model would seem to be appropriate for CPR training.

OTHER KEY ASPECTS OF LEARNING AND MEMORY

Cognitive research has uncovered several other variables that impact the durability of information and skills in memory. Tolman (1938) shows that learning takes place because of goal-oriented behaviour. This is another form of motivation that helps us focus on learning skills that serve some other purpose. For example, people study not only because they are reinforced to study but also because studying leads to intermediate goals that allow a person to reach an ultimate goal. This emphasizes the importance of promoting motivation to learn CPR. If saving a life is given personal meaning, then learning CPR and ones role in the chain of survival become key parts in developing the motivation needed to focus and pay attention to the learning process.

Incidental learning refers to information stored in memory as a result of life experiences that are secondary to some other purposeful behaviour (Glass & Holyoak, 1986). Most of our memories are stored as a result of incidental learning that provides a storehouse of information about how to interact with our environment. This stresses the importance of providing students with exposure to situations, either directly or indirectly, that make CPR and their role in the chain of survival personally meaningful. Another model, latent learning, suggests that having gone through learning but without reinforcement still has benefits that show up when the reward is provided.

Finally, all research studies, as well as the practical application of teaching methodology, show that there are individual differences in learning styles. For example, each person's relative preference for visual versus semantic/symbolic encoding impacts the ability to create quality representations in long-term memory and efficient short-term memory cues for later retrieval.

KEY MESSAGES

Based on research in cognitive science, the following points are important considerations in the design of optimal teaching methodologies for enhancing retention when training adolescents in CPR and in their role in the chain of survival:

- Motivate adolescents in believing that CPR will allow them to have a real impact on people they care about. Make the event of cardiac arrest personally impacting
    - Some suggestions include making CPR's value a part of the school culture, part of the peer culture and part of the home culture. Provide meaningful testimonies of successes and failures through age-appropriate presentations, videos, and website information/activities. Provide training scenarios that mimic the real-world event as closely as possible. Although not everyone will be motivated right away, incidental learning theory shows that the mere exposure to meaningful real-life situations will at some point impact adolescents
- Reinforce that putting effort into learning CPR training properly is a means to an end that is personally important to them
- Consider context issues
    - Matching the way in which CPR is learned to the way in which it will be recalled will dramatically improve recall
        - Since in the real world situation, adolescents will be called upon to recognize cues and initiate the proper sequence of actions, CPR training needs to be hands-on with as little theory as possible. In the real-world event, adolescents will not be talking about CPR, they will have to recognize the right cues and act immediately
        - This will also decrease the amount of extraneous information that interferes with acquisition of the skill
    - Incorporate the pressures of real-life emergency into the training
    - Promote visualization of a specific scenario from the training context as a strategy to use when in the real-life emergency situation. Research shows that recalling the original learning context will significantly improve recall
- Immediate and relevant feedback is extremely important in preventing errors from being learned and in strengthening associations among proper sequenced actions in response to cues
- Consistency of information presented during training is critical in order to minimize the teaching of errors or extraneous information. As an example, the use

of a CPR training video is very helpful in consistently presenting the correct information. In this case, the teacher could serve as facilitator in order to provide feedback

- Removing from training any extraneous information that is not directly related to CPR skills is critical in ensuring that optimal acquisition. Allowing the learner to focus on the target information provides the basis for good retention
- Finally, practice plays a key role in reinforcing the quality of the memory of CPR skills, the recognition of appropriate emergency cues, and the linking of the two

The Social Psychology of the Bystander Effect

EFFECTIVE USE OF CPR WHEN YOU ARE NOT ALONE

Classic studies on the psychology of pro-social behaviour have demonstrated a reliable and perplexing effect. Although people may feel comfort and safety at having others around, research shows that the greater the number of people present at an incident, the less likely that any one person will help (Darley & Latane, 1968; Latane & Darley, 1968). This behaviour, or lack of, is explained by the "diffusion of responsibility"; the belief that someone else will take action so that no one feels personally responsible. The most famous example is that of Kitty Genovese, a 19-year-old woman who was murdered in 1964, in New York. Her screams were heard as 38 neighbours watched her being beaten to death in an attack that lasted half an hour. Although there was ample time to intervene or call the police, Kitty's neighbours chose to do nothing but watch (New York Times, 1964).

The root cause of the bystander effect that allowed this horrible crime to continue unabated is believed to be the absence of felt responsibility. In order for observers to intervene they must feel personally responsible for the outcome. What does it take then for people to feel personally responsible? Latane & Darley (1970) describe five necessary

steps that lead to bystander intervention. People must 1) Notice the event; 2) Interpret the event as an emergency; 3) Feel personal responsibility for acting; 4) Consider what form of assistance is needed; and, 5) Implement action. Two factors impact these stages. The first three steps are least likely when other people are around. Research shows that a victim is most likely to receive help when only one other person is present because that person is unable to transfer to anyone else the responsibility for intervening. The likelihood of intervention decreases dramatically as the number of observers increases, with the greatest change occurring when one observer is added to the victim and helper. Even when people notice the event and interpret it as an emergency and want to act, observing the passivity of other people impacts the fifth stage through "inhibition of action" which reinforces the diffusion of responsibility. The natural tendency for inhibition of action occurs because of the observation that other people appear calm. This apparent calmness reinforces the bystander's inhibition of action and contributes to all bystanders fooling each other into believing that everyone is calm, and therefore, there is no emergency.

"Inhibition of action" may also have an indirect impact on the ability to perform CPR by creating doubt, and therefore, reducing the motivation needed to remain focused, and retrieve and use learned skills in an automatic procedural fashion. The bystander effect has been observed in many contexts, for example victims of seizures (Schwartz & Clausen, 1970), theft of belongings in a library (Shaffer, Rogel & Hendrick, 1975), shoplifting (Bickman & Rosenbaum, 1977), preventing a peer from driving while drunk (Bickman & Rosenbaum, 1977), and in general, failing to act quickly (Perez, Braslow & Bock, 1992).

Compounding the bystander effect may be the reluctance on the part of bystanders to administer CPR for other reasons. In a survey of 1,012 lay people from Sweden recently-trained in CPR, Axelsson, Thoren, Holmberg, et al (2000) assessed attitudes and beliefs towards the risk of contracting serious diseases and found a difference between willingness to administer CPR to strangers versus someone they knew. They found that 94% believed there was a minor to major risk of serious disease transmission while

performing CPR. Specifically, 17% would not start CPR on a drug addict, 7% would not perform CPR on an unkempt man. But 97% were sure they would perform CPR on a relative, and 91% on a known person. Respondents from rural areas were significantly more likely than respondents from metropolitan areas to state that they would be willing to perform CPR. Education is needed to remove this barrier.

KEY MESSAGES

This research implies that the apparently poor performance of bystanders in administering CPR in real emergencies may in part be an artefact of the bystander effect, both because of the natural reluctance to help, and the potential impact on confidence. Providing training that addresses the root cause of the bystander effect will increase involvement in emergencies and improve the quality and reliability of the CPR administered. Here are some key points to consider for training methodology:

- The ability to administer CPR effectively must be made to be personally important to adolescents. They must also be trained to feel personally responsible for administering CPR correctly and, more generally, for playing an effective role in the chain of survival
- Training should ensure that lay emergency providers interpret the public situation unequivocally as an emergency and act immediately regardless of the level of involvement by bystanders. Since interpretation of social and behavioural cues is critical in engaging CPR sequence, training adolescents to be biased towards interpreting the situation as an emergency will help counter the bystander effect by reinforcing that assessment of a situation involves action first
- Since reinforcement of helping behaviour will occur when bystanders also help, training should emphasize the need to directly involve bystanders in helping. This will act by breaking the impact of "inhibition of action" and reinforcing the reality of the emergency, the importance of personal responsibility and the relevance of performing the appropriate procedural CPR sequence

- In all of the above, realism of the training scenarios and all other context factors discussed in the previous section are key in countering the bystander effect
- Ensure that accurate information about the health risks to the helper are clearly conveyed and understood

Importance of Motivation in Adolescents

In the case of adolescents, we know that brain physiology is undergoing tremendous change, not so much in mass as in connectivity between neurons and various areas of the brain. As a result, real-life experience has a tremendous formative impact not only on personality, but also on how they will respond to emergency situations. Critical to this age group is the relevance of what they are being taught. Adolescents only invest effort into endeavours that are personally meaningful. As noted earlier, attention is a key component for the acquisition of information in long-term memory. Without attention, none of the teaching strategies will be effective in creating high quality, long-term memory storage, the development of efficient retrieval cues in short-term memory, or in the creation of cognitive re-structuring that will help adolescents counteract the powerful effect of diffusion of responsibility. Once an adolescent is engaged and passionate, learning follows very quickly. This is a major challenge for CPR training as in any area of education. In order to maximize retention and significantly increase the likelihood of adolescents taking an active role in the chain of survival, CPR has to be made personally meaningful by increasing the chances that they will feel personally impacted.

Latest Developments in CPR Training for Enhancing Real-world Performance in Adolescents

A New Direction

Several lines of research and practice are being pursued for the purpose of increasing the base level of CPR skills in lay people, especially adolescents, by promoting the key role that lay people (mostly relatives and friends) play in the chain of survival, improving education of the general public in order to increase involvement in learning skills, promoting Basic Life Support as the first link in the chain of survival, and using research findings in cognitive and social psychology to create optimal training (AHA, 1992; Bircher et al, 1996; Cummings, Chamberlain et al, 1991; Safar, Bircher et al, 1988).

Of particular concern in this review has been the cognitive, motivational and social psychological aspects of learning and memory that impact the retention and use of CPR skills. Research that began in the mid 1990s strongly suggests that improving retention and use requires that traditional methods for teaching CPR be replaced with novel approaches that incorporate findings from the scientific literature focused on instilling effective behaviours in real-world contexts. As described earlier, Braslow, Brennen, Newman, et al (1997) summarized results from the research literature into 12 short-comings of the traditional didactic approach to teaching CPR. One additional issue that is especially important for adolescents is the creation of a learning environment where a student can gain control over their own learning (Benson et al, 1996; Bircher et al, 1996). All of these issues parallel closely the research literature in learning and memory that has identified several key factors necessary for promoting efficient acquisition of skills/knowledge, durability of the sequence in memory, and effective recall in real-world situations.

This last section of the review describes areas of research and application that point to, and in some cases demonstrate, the potential for significant improvements in CPR retention and use in real-world emergencies. These strategies are particularly relevant to adolescents.

THE EXPERIENTIAL LEARNING MODEL

The Experiential Learning model (Kidd & Kendall, 2007) provides a comprehensive framework for optimizing teaching methodology. Specifically, experiential learning involves learning by observing and doing, role playing, realistic and age-appropriate simulations, scenario-based sequences, effective and timely feedback, smaller groups than traditionally used, lecture-based approach replaced with facilitated and interactive teaching. According to research, experiential learning incorporates key elements from cognitive, motivational and social psychology to promote deep learning and maximize the reliable and effective recall of learned skills (Daley, 2001; Nicklin & Kenworthy, 2000, Zimmerman & Phillips, 2000). Essentially, the model involves moving the participants from a learning process that matches the real-world context in which it will be used, to feedback and reflection on one's performance, to more practice that incorporates new insights. This is an iterative process that can be used to reinforce not only the sequence of CPR-specific steps, but to incorporate motivational and social psychological components needed to deal with the complexity of real-world situations. While true experiential learning involves the development of complex and expensive real-world simulations in order to mimic all aspects of real-world emergencies to the fullest (Burton, 2002; Henry, 1997; Scherer et al., 2003), some promising, affordable and practical alternatives seem to suit the needs of teaching CPR in high school settings, and the context of the adolescent's role in the chain or survival.

VIDEO-ASSISTED LEARNING

Video-assisted CPR training provides an opportunity to incorporate key aspects of the experiential learning model and key concepts from the scientific literature into teaching methodology that is both more affordable and more useful for the practical limitations of a high-school teaching environment. The use of a simpler tool with adolescents compared to the sophisticated tools used in full experiential learning for health professionals is consistent with the now accepted view that training for lay people should be consistent with their simpler role in the chain of survival (AHA, 2005; Chamberlain & Hazinski, 2003). Introduced by Braslow, Brennan, Newman, et al (1997), the CPR video has become a catalyst in promoting other improvements to teaching methodology.

Building on a review of the research literature on the limitations of the traditional teaching of CPR, and on focus groups to determine optimal design, language, instructions, and organization of content, Braslow et al (1997) developed a video intended for self-instruction in the home. Designed for 30 minutes the video represented a significant departure from the traditional teaching of CPR and a significant attempt to incorporate key research on learning and memory by requiring the learner to "mimic what they see." Specifically, material unrelated to CPR skills was significantly reduced allowing the learner to focus on the essential sequence of steps. In addition, CPR concepts were incorporated into the learning of the sequence steps rather than merely explained. The use of complex and unintuitive language was reduced, and the relationship between learner action and victim impact was maximized. In this hands-on context, it becomes much easier to give useful and timely feedback to the learner. A mnemonic tool was added for the assessment thus creating an efficient retrieval cue. Sequence of steps was simple and logical. Effective practice time was increased.

Simplification of course material has also been documented in a study of Grade 8 students (Kelley et al, 2006) that found that a condensed version (50 minutes) of the AHA standard CPR course resulted in good acquisition of CPR /AED skills (87% pass

rate) and good retention of skills 4 weeks after training (84% pass rate). The training consisted of a lecture/demonstration session with the entire group followed by a hands-on practice session in which students formed a line and went through the arrest scenario, returned to the end of the line and went through the scenario again. Each student had the opportunity to observe their peers in scenario and practiced through the scenario again with knowledge gained from observing their peers. The modified course removed most of the extraneous information not related to CPR/AED that is part of the standard course, focused more on practice, and focused on the most common victim of cardiac arrest, the adult.

The 1997 study, and several others, provided evidence that the "practice while you watch" method achieved significantly better results in a much shorter period of time than the traditional teaching method, even when learners were re-tested after significant delays since initial training. The results were replicated in a range of populations including, for example, health professionals, general population and individuals over the age of 40 (Batcheller, Brennan, Braslow, et al, 2000; Braslow, Brennan, Newman, et al, 1997; Lynch et al, 2005; Stapleton & Aufderheide, 2001; Todd, Braslow, Brennan, et al, 1998). As an example, Todd et al (1998) found the following advantages of video-assisted learning of CPR over traditional methodology. They found that 43% of traditional trainees were judged not competent to perform CPR compared with only 18% of video trainees. Of the video trainees, 81% could open the airway after the first set of chest compressions, and 71% could open the airway between subsequent sets, compared with 43% and 34%, respectively, of traditional trainees. The median chest-compression rate and number of total and perfect compressions were similar for both groups over the 2-minute testing period. Research suggests that video-assisted learning provides a viable alternative to the traditional teaching method. Given the significant reduction in training time needed to achieve significant results, and the reduced load on teacher preparation, this new methodology would be ideal for high school settings where teachers express concern over workload. Reduced length of training is more likely to suit the often short attention span of adolescents, and provide more opportunity to incorporate other aspects of training required to support high school students in being effective members of the

chain of survival. As mentioned earlier, reducing the amount of time needed to teach CPR would leave more time for training related to motivation and dealing with the bystander effect. The

Because of its success, this approach has been widely promoted to the international community (Chamberlain & Hazinski, 2003) and more recently incorporated into the American Red Cross' and the American Heart Association's curriculum (AHA, 2005). The video is used in-class and provides the instructor with the ability to give better feedback to students as they are training themselves. Stapleton & Aufderheide (2001) summarize the value of using a CPR video: "Video-based courses can present information in a highly visual and consistent format. Videos can communicate clearly organized content using highly stimulating scenario-based presentations, graphics and dynamic animations to clarify concepts. The skills presented in video are delivered in a consistent manner during each course, with special attention to the viewer's perspective of each skill component. With video demonstration, participants can closely observe rescuer hand position, finger position, mannequin chest rise, and other key components of the skill. These qualities in combination with instructor feedback, can significantly improve participant acquisition of both cognitive information and psychomotor skill" (p.3).

TEACHER AS FACILITATOR

The new trend in CPR instruction is to use the teacher as a facilitator of the learning process. Given the overwhelming evidence that learning occurs through observation and practice, the introduction of, for example, video-assisted learning, requires that the teacher support the learning process by providing useful and timely feedback to students, coordinating activities, and managing classroom dynamics (Fong et al, 2001; Starr, 1998; Wik et al, 2002). Examples of teaching techniques that promote the facilitator role include video-based techniques, television, hands-on practice iterations (Chamberlain & Hazinski, 2003).

IMPROVING FEEDBACK

Feedback is a key component of learning because it supports the learner in committing the proper sequence of CPR actions to long-term memory. In order to be effective, feedback must be tightly linked to the learner's action, and act by reinforcing the desired user behaviour and correcting errors. Feedback must also be useful i.e. it must provide the learner with insight that is geared toward that person's learning style. Confidence is built-up by supporting the learner in properly self-assessing their performance and understanding what to correct and how. Research shows that merely providing encouraging words or stating whether a behaviour is correct or not leads to a mismatch between confidence and actual performance known as the overconfidence effect (Petrusic & Baranski, 1997). The video-assisted learning methodology provides the opportunity for relevant and timely feedback to the learner. In a high-school environment, this could be provided by the teacher who performs the role of facilitator, or by a previously trained peer. These forms of feedback are highly dependent on consistency, training, availability, and motivation.

Alternative methods of feedback provided by computer-based methodology could further enhance the level of feedback. Since proper CPR involves the continued assessment and adjustment of one's compressions and ventilations based on visual and auditory cues, computer systems incorporated into the practice mannequins could provide useful feedback. Both visual and auditory feedback has been shown to significantly improve acquisition and retention of CPR even six months after initial training in both medical professionals and lay persons (Berg, Cobb, Doherty et al, 2001; Handley & Handley, 2003; Wik et al, 2001, 2002) by providing auditory corrective instructions when errors are detected.

PEER TRAINING

Some research suggests that training by trained peers is just as good as that provided by professional CPR trainers. Wik, Brennen and Braslow (1995) trained factory

workers in CPR who then trained family members and fellow workers at home using a cardboard mannequin. The results indicated that peer training was as effective as that provided by instructor-led CPR courses on most aspects of CPR and outperformed the traditional instructor training in number of compressions and ventilations. Peer training provides a potentially useful alternative to traditional training when it is not available. The idea of peer training may also be useful with respect to the motivational aspect of CPR where adolescents are concerned. As described earlier in this paper, motivation is a critical factor in ensuring optimal attention during training, especially with adolescents. Without attention, short-term memory will not create quality representations of CPR skills and will not associate appropriate cues. We also know that peer influence is one of the strongest motivational factors in the learning and transfer of behaviour between adolescents. There is untapped potential for increasing student motivation by involving previous CPR students in the training of new students. For example, one possibility is to pair new students with previously trained students in order to enhance the experience. Coupled with video-assisted learning and the facilitation role of the instructor, feedback from a peer may enhance learning, retention and the desire to be an effective member of the chain of survival when the need arises.

INCIDENTAL LEARNING: MAKING CPR A PART OF STUDENT CULTURE

Research on the cognitive science of learning and memory and in social psychology (Fiske, 2004), mere exposure to experiences changes how people think and see the world. This also applies to CPR. As an example, consider the case study (Eisenman, Rusetski, Zohar et al, 2005) of a 71 year-old woman who saved the life of her husband of the same age, by applying what she remembered of CPR incidents she had watched on her favourite medical TV show. She had no previous training in CPR and had no sense of whether she could perform CPR effectively. After administering compressions and ventilations to the best of her ability she noticed that her husband seemed to be gaining some control. She took the opportunity to call emergency, and then, she continued to perform compressions and ventilation until the emergency team arrived, 15 minutes later. At this point, medics administered CPR, defibrillated, after which he returned to normal

pulse and blood pressure. The man was taken to the hospital and then discharged one week later without any neurological impacts. Given the 15-minute time lag between the beginning of cardiac arrest and the restoration of pulse and blood pressure, it is clear that the compressions and ventilations provided by his wife were effective despite the fact that she had no formal training in CPR.

Although only a case study, this incident is a clear example of the power of incidental learning that has been well documented in the cognitive research literature, and points to the real opportunity to promote not only CPR skills in students but also to enhance motivation. A preliminary web-based survey focused on listing potential opportunities for providing incidental learning in high schools could be followed by focus groups to determine what avenues might be the most successful. Films and television or programs where CPR is shown to save the life of engaging characters is one possibility. Live or web-based presentations of CPR stories involving family, friends and students may also provide other opportunities. School-based campaigns for other causes that have been successful in modeling desired behaviour in students could also be a source of useful strategies.

STAGED TEACHING: HOW NOT TO TEACH CPR

The Staged Method of teaching CPR consists of breaking down skill acquisition into components and building complexity over subsequent stages (Chamberlain, Smith, Colquhoun et al, 2001). Specifically, the first stage involves teaching and practicing compression only, without ventilation. The second stage incorporates ventilation with compression. And the final stage moves the learner to practicing the full CPR sequence. The basic premise is that acquisition and retention of the full CPR sequence will be improved by supporting the learner in first mastering subsets of the CPR sequence steps. A subsequent study showed failure to acquire skills and rapid decay of 6 months after training with this methodology. Even conventional refreshers had little impact or value (Chamberlain, Smith, Woollard et al, 2002).

These results are not surprising given what cognitive science has taught us about the learning of procedural information. Specifically, in learning a sequence, each step serves as a stimulus for the next action in the sequence. Associations are strengthened through practice and feedback. However, the stage method reduces the quality of the full CPR sequence by forcing the learner to break the sequence learned in a previous stage by inserting new steps into subsequent stages e.g. introducing ventilation in with compressions. The learner now has to go through the task of breaking stimulus-action associations learned during the previous phase and redefine and re-establish new associations in the second phase. This requires a considerable amount of short-term memory resources and additional practices to replace existing information in long-term memory. The associations are further complicated because now the learner has to track ratios of ventilations to compressions. As we know from cognitive research, the intellectual task of tracking ratios will be very taxing on short-term memory resources required for establishing sequence associations. Finally, research has established that optimal learning and recall take place when the learning process matches the real-world retrieval requirements. Real-world application of CPR does not take place in stages. The artificiality of this method also makes it difficult to incorporate real-life scenarios that are so important in motivating adolescents to learn CPR. As a result, it is strongly recommended that the stage method of learning not be used for teaching CPR. It complicates the learning process and is likely to result in poor acquisition, rapid decay, and difficulty in effectively applying the appropriate sequence in a real-life emergency.

Conclusion

In conclusion, this review of the research literature demonstrated that the retention and use of CPR skills is much more complex than previously thought. There are many cognitive, motivational and social psychological factors that determine how well the sequence is learned and how effective its recall and use will be, whether in a test situation or in a real-life emergency. Having said this, these principles, extracted from the research literature, have already experienced significant integration into new tools and teaching methodologies resulting in higher rates of recall than previous studies. Moreover, these new tools and teaching methodologies can significantly shorten training time and be

conducted at a reasonable cost, suggesting that they are well-suited for integration into the high school teaching curriculum. Additionally, the low retention rates reported are partly an artefact of the assessment criteria that include an unreliable factor, the carotid check. The pulse check has been found to be unreliable and to result in cases where the refusal to administer CPR was based on the erroneous detection of a pulse, when in fact the victim was in cardiac arrest. This decision occurs because of the unfounded fear of causing additional serious health problems in the victim if he/she is not actually in cardiac arrest when CPR is administered. Removing the pulse check has resulted in higher performance statistics.

Given that the vast majority of cardiac arrests take place in the home, the training of lay people in CPR plays a critical role in initiating the chain of survival and administering CPR early enough to make a difference. Adolescents are seen by CPR training agencies as the key cross-section of society to target for several reasons. Adolescents learn quickly given the appropriate motivation, social factors and experiential teaching methodology. Adolescents will one day run households of their own, and as such their own motivation to learn CPR is likely to provide a significant influence in promoting CPR skills in their own families, thus further increasing the base level of CPR skills in society. Finally, implementing CPR programs in high schools provides an unparalleled opportunity to train large numbers of people in short periods of time in a consistent way from year to year.

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