Olfactory Reinforcement of a Paired Associate Learning Task

I. Description of Need

Acquisition of factual knowledge is a necessary skill in any educational setting. This type of learning requires a great deal of deliberate practice (Ericsson, Krampe, & Tesch-Romer, 1993), much of which relies on the learner’s motivation to regularly expend the effort required to attain long-term retention, and timely recall. Individuals fail to acquire factual information (and other kinds of content for that matter) for reasons that may include low levels of interest (Cameron, Banko & Pierce, 2001), motivation (Mayer, 1998), or lack of strategies required for effective self-coaching (Mondria, & Mondria-De Vries, 1994). As such, learners who endeavor to learn new content may feel, and actually be, unqualified to effectively manage their own learning.

Researchers point to time on task as one of the fundamental features of achieving expert levels of performance. Depending on the content, some learners may feel less motivated than others to spend the time on task that is required to learn a new language, or other kinds of factual knowledge. As such, research findings point to the value of extrinsic rewards for the enhancement of time on task (Deci, 1971, as cited in Akin-Little, Eckert, Lovett & Little, 2004).

Learners who do not have the financial means to acquire expensive learning technologies (i.e., the computer), may be unaware of non-electronic technologies that could contribute to
more effective acquisition of factual content. This product is tailored primarily to individuals who want to enhance their learning, but are limited in resources.

Another potential set of users could be learners who do have the means of purchasing a computer, but who want to use a non-electronic means for content mastery. A product such as the one described herein may present alternatives to self-study not previously available, or widely publicized.

The purpose of this project is to design an instructional product that promotes effective presentation of factual content, and incorporates motivation-enhancing extrinsic rewards that promote retention. The product constitutes Leitner’s hand computer (as described by Mondria and Mondria-De Vries, 1994), and also includes a system for scheduled delivery of olfactory-based reinforcement that aims to augment retention through re-creation of the original learning environment. Literature to support the chosen approaches for designing the product is documented in the Scientific Principles section of this paper.

II. Search Strategies

The majority of the research regarding learning, memory and reinforcement is found in the literature reviewed during the course of the semester. Research literature on the use of olfactory cues to enhance learning has been conducted through Utah State University Library online journal searches. Primary search databases include Wilson Web (Education Full Text), ERIC, and PsycINFO (Psychology and Behavioral Sciences Collection). Search terms include:

Attitude, Cognition, Learning, Machine, Memory, Meta-analysis, Mood, Motivation, Odor, Odor Recognition, Olfaction, Paired Associates, Performance, Prescription,
III. Scientific Principles

The scientific principles described in the next section, which are incorporated into the product include:

Spacing effect
Expanding rehearsal
Reinforcement
Time on task
Motivation
Feedback
Positive affect

a. Spacing effect

Rea and Modigliani (1988) recommend using the spacing effect as an approach to learning in that “spaced (or distributed) practice is better than massed practice, and that the effectiveness of repetition increases with spacing between them” (p. 402). While it could be noted that practicing a group of 20 to 30 word pairs is in fact massed practice, the chosen method by which this product presents the word pairs corresponds to the spacing effect in that each item to be learned is distributed across various ratios of time. Additionally, the product instructions (listed in the Planned Implementation section) recommend practice sessions to be about 15 to 20 minutes in length.
b. Expanding rehearsal strategy

Landauer and Bjork (1978) recommend the use of increased time increments when acquiring factual knowledge such as people’s names. Supportively, Mondria and Mondria-De Vries (1994) state that expanding rehearsal strategy “advocates that a given item should be tested after a very brief delay. If the subject correctly recalls it, the delay should be systematically increased, whereas, if (s)he is wrong the delay should be shortened” (p. 50).

Rea and Modigliani (1988) cite Siegel and Misselt’s (1984) program, which successfully presented English-Japanese word pairs using CBI. The program was effective due to the “increased ratio review technique” (p. 404), as well as distributed practice. Incorrect items were re-presented at predetermined ratios of 3, 6, and 10, thus a learner would find it difficult to predict when an incorrect item would be re-tested. Such a practice of random item generation disables learners from memorizing lists, rather than items.

c. Reinforcement

Expanding schedules of reinforcement are also incorporated into the product design. According to Cameron, Pierce, Cameron, & Pierce (2002), reinforcement of correct behaviors should be continuous at first and then intermittent in later stages of learning. Cameron et al. (2002) identify two major factors that contribute to necessary reinforcement: immediacy and certainty.

Reinforcement should only take place immediately after the correct behaviors are being exemplified, thus avoiding issues with delay. Although Cameron et al. (2002) do cite potential
problems if delay of reinforcement occurs, it’s most important to reinforce target behaviors while they are taking place, and not to reinforce incorrect or undesired behaviors when they occur.

Once a behavior is established, Cameron et al. (2002) suggest moving to a schedule of reinforcement intermittency and also prescribe a variable-ratio schedule as most effective. As such, a desired behavior can be reinforced at any given time with the ratio eventually increasing “so that high levels of performance are maintained by very infrequent reinforcement” (no page). Miltenberger and Fuqua (1983) also attest to the effectiveness of variable-ratio schedules when they tested such a schedule’s application to rate of workplace performance.

d. Time on Task

Ericsson, Krampe & Tesch-Romer (1993) cite time on task, intensity, and structure of training as the three factors that play the most significant role in achieving expert levels of performance. As cited earlier, extrinsic rewards have been shown to increase learner willingness to spend more time on task (Deci, 1971, as cited in Akin-Little et al., 2004). Ericsson, et al. (1993) cite Galton’s (1869/1979) “claim that motivation and perseverance are necessary for attainment of eminent performance” (p. 366), and further state the most cited condition for learning performance “concerns the subject’s motivation to attend to the task and exert effort” (p. 367).

A correlation also exists between eminent academics and the amount of time they spend writing. Compared to non-eminent academics, eminent performers “produce a much larger number of publications than other scientists. It is clear from biographies of famous scientists that the time the individual spends thinking, mostly in the context of writing papers and books, appears to be the most relevant as well as demanding activity” (p. 391-392, as cited in Simonton, 1988).
e. Motivation

Mayer (1998) suggests that motivation, along with cognitive skills and metaskills, is one of the three fundamental skills for learner success. Although he agrees with Dewey (1913) that extrinsic motivators may be damaging to learner performance (more specifically, to creativity and persistence), Cameron, et al. (2001) suggest that motivating students in an extrinsic manner is not damaging to learner performance. Supportively, Bryan and Harter (1897, 1899, as cited in Ericsson, et al., 1993) find that Morse code operators, after reaching plateaus of learning, “could be encouraged to dramatically increase their performance through deliberate efforts when further improvements were required for promotions and external rewards” (p. 365). Mager (1968) simply suggests that when the student is in the presence of subject matter, he should at the same time be in the presence of positive conditions. Conversely, when the student is in the presence of subject matter, he should not at the same time be in the presence of aversive conditions.

e. Feedback

Verification feedback (Mason & Bruning, n.d.) involves informing the learner whether or not performance is correct or incorrect. In the case of learning non-contextualized word pairs, which is a lower level task, feedback should be immediate and should provide verification as to whether or not the item was or was not identified correctly.
f. Positive affect

Although the debate concerning extrinsic and intrinsic motivation rages on (Cameron et al., 2001; Cameron et al., 2002; Akin-Little et al., 2004), the fact remains that student performance: 1) is not damaged by extrinsic motivation, and 2) can be reinforced using environmental cues. The environmental cue employed in this product is the use of olfactory stimuli, which has been studied for a variety of applications that include learning enhancement. Research indicates that olfactory stimuli can be effectively used as cues for context enhancement (Lawless & Engen, 1977), emotional connection to past (Herz & Schooler, 2002), mood (Herz, 2002), magnetic-resonance imaging (MRI) anxiety (Redd & Manne, n.d., cited in Green, 1993), dental office anxiety (Lehrner, Eckersberger, Walla, Potsch, and Deecke, 2000, cited in Cohn, 2001), pleasant and unpleasant memory stimulation (Ehrlichman and Halpern, 1988), and short-term association (Bowers & Doran, 1994; Engen & Eimas, 1973; Engen & Ross, 1973).

One study, (Knasko, et al., 1990, cited in Lorig, 1992) demonstrates that even the expectation of an odor’s presence in the room could influence states of emotional well-being. Although a positive, negative or neutral odor was promised to be present in participants’ hospital rooms, no odor was ever present. Subjects who anticipated a positive odor reported fewer poor health symptoms and rated themselves as having a more pleasant mood (Cohn, 2001).

The use of olfactory stimuli is a viable approach for fostering long-term connection with subject matter, pleasant extrinsic motivation, and immediate verification feedback. “Recall is proposed to be better if the learned information is recalled in its original learning environment rather than a different location” (Cohn, 2001, p. 99). Because people frequently have to recall
information learned outside the original learning environment, olfactory cues are a viable option because of their ability to recreate at least one element of that environment, the scent.

Although there are some latency and habituation issues, olfaction taking the longest amount of processing time among the senses (Woronczuk, Medwid, Neumann, Eshelman, n.d.), some advantages are that olfactory cues do not cross with the visual or auditory channels (the two primary senses used for learning), they don’t demand a significant amount of cognitive load, nor do they contribute to the split attention affect (Cooper, 1998). Reintroducing any elements in common with the learning environment “such as odor is sufficient to improve recall of the learned stimuli, presumably through facilitating the retrieval process rather than strengthening the memory trace per se” (Smith et al, 1992, p. 343, as cited in Cohn, 2001, p. 99).

Results vary when determining which scents may be more effectively used for learning. In a study to determine which scent would be more appropriate to use (lavender or rosemary) Moss, Cook, Wesnes & Duckett (2003) found that “rosemary produced a significant enhancement of performance for overall quality of memory” (p. 15) over lavender. Cohn (2001) on the other hand, finds no significant difference in the selection and use of prescribed scents for enhancing recall. None of the scents she tested performed at a significantly higher level than did other scents serving as learning cues.

**IV. Planned Implementation**

The design of an olfactory-enhanced hand computer is comprised of the following materials:

- Specific content to be learned. This is learner dependent, but should be consistent for the student’s level of prior knowledge.
• Leitner’s hand computer as described in Mondria & Mondria-De Vries (1994).

• A mechanism for release of olfactory stimuli. This could range from complex (Digiscents’ electronic odor emitter) to simple (scent candle with non-permeable lid). Whichever mechanism is chosen, a variety of scents should be available for the learner to choose from. Such a method is suggested by Cameron et al. (2002) who claims that asking people what they like the best is a simple way to identify positive reinforcers.

An economical method for using a scented candle is to punch a hole in a piece of paper, cut it to fit the shape of the candle’s container, then glue it to the container (use a non-odorous glue that won’t cause interference). When reinforcing a correct behavior, hold the candle close to the nose with the hole in line with the nostrils. Tap the paper to release a sufficient supply of the scent toward the nose.

• Instructions for reinforcement.

• Instructions for using the hand computer.

a. Reinforcement Instructions

Week 1: Each correct item is reinforced by an inhalation of a chosen scent. The chosen scent must remain as the constant reinforcing element through the duration of study, as well as test taking. In this particular demonstration, a scented candle with a glued-on paper lid is employed. Such reinforcement should be immediate, or directly after correct items are identified. Such a method of immediacy is more effective than delayed (Mason & Bruning, n.d.). Practice sessions should not exceed two hours (Ericsson, Krampe & Tesch-Romer, 1993) and are recommended to about 15 to 20 minutes per session.

Week 2: Reinforce every other correct item.
Week 3: Reinforce every fifth correct item.

Week 4: Move to a variable-ratio schedule of reinforcement in which correct items are reinforced, for example, every 2, 8, 2, 4, 1, 9 times. Such a method should raise levels of reinforcement expectancy.

Week 4+: Correct items are reinforced on a similar variable-ratio schedule, but with increasing levels of time between the reinforced items. Such a schedule could be represented by 7, 6, 10, 5, 12, 8.

Testing: Learners should be exposed to a sample of the reinforcing scent that was used during the practice sessions. This exposure should take place during the entire testing period at levels similar to those experienced during the learning phase.

**b. Hand Computer Instructions**

The hand computer device is explained by Mondria & Mondria-De Vries (1994, p. 52) and is paraphrased herein.

1. Limit practice sessions to 15-20 minutes.

2. Write or type words to be learned using one card per word, the foreign-language word on one side, the translation on the other (preferably in a different color so that it is immediately clear which is the front and which is the back).

3. Place 30-40 cards (at most) in compartment 1. For the sake of simplicity, this demonstration uses only 5 cards at a time.

4. Look at the English language word, and allow for about 1 second to respond before looking at the foreign-language word.
5. Go through the set of cards, placing the words known in the back of compartment 2, and the words not known in the back of compartment 1.

6. Replenish compartment 1 with 30-40 new words when there only three words left in compartment 1.

7. Review the new words in compartment 1, as well as the incorrect items from the first attempt with compartment 1. Any correct items go to the back of compartment 2, incorrect items remain in compartment 1.

8. Repeat steps 2-7 a few times, thus filling up compartment 2.

9. Empty compartment 1 by mastering those word pairs.

10. Review all word pairs in compartment 2.

11. Place words still known in compartment 3. What is not recalled goes to the back of compartment 1.

12. Empty compartment 2 in the above manner and then repeat the process so compartments 3 and 4 are also full.

13. Continue to review word pairs placing whatever is known in the next compartment, and anything not known, or no longer known into compartment 1. Compartment 5 contains the complete word knowledge of a given set of items.

V. Testing Strategy

Treatment and control groups are randomly assigned in order to test the effectiveness of the approach. Pre-tests establish prior knowledge of content and provide an initial benchmark from which to measure gains (or losses!). All subjects are pre-tested in the same location (L1), none of which are exposed to a scent of any kind.
During the learning phase (1 month duration), which also takes place at L1 for all groups, control groups are not reinforced by the scent, but treatment groups are reinforced, their schedules remaining identical across all treatment groups. Although it is possible that subjects might review the word pairs outside of the experiment, it is expected that this variable will affect both groups equally as a large enough sample size, and random assignment should ensure outliers wouldn’t corrupt the data. A similar possibility also exists with the chosen reinforcing scent. Unintended exposure to the scent may occur for some of the participants during the learning phase, or between the learning phase and post-test, but random assignment and sample size should also compensate.

Once the learning phase is complete, post-tests are conducted two weeks after the last training session. Table 1 depicts the method by which post-tests are administered to each group. Note that L2 is introduced as a second location where some subjects will receive their post-test. Such an approach attempts to isolate the independent variable (scent) and also tests whether or not the IV is strong enough to assist recall performance outside of the original learning environment.
Table 1. Arrangement of experimental groups, and administration of the learning phase and post-test.

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C: Control   T: Treatment   L: Location
Expected results are that the mean group post-test scores of T1 and T2 will be the highest of all groups. Likely, C1, C3, and T3 will also rank higher than the remaining groups because L1 is common to both their learning and post-test.

VI. Discussion

Only one approach has been described in this particular testing strategy, thus further opportunities exist for testing other variables. One method may be to run further tests on location of learning and testing and how those variables influence outcomes. Also not studied here is the intensity of the olfactory reinforcement. An electronic scent emission device would ensure that all subjects are exposed to similar intensities of the reinforcing odor. Additional research opportunities exist that examine duration. These may include learning phase, time between learning and post-test, and time of exposure to the reinforcing odor.
References


