Application of Genetic Algorithm to Keyboard Arrangement Problem

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ABSTRACT

The number of people who use computer for business purposes increases as technology grows. Application of ergonomics practices on computer workstations reduces musculoskeletal discomfort experienced and increased overall job satisfaction of the employees. Keyboards are available in various systems, computers to mobile devices, which have difference shapes and sizes. Keyboard size and shape is known to influence upper extremities. Alternative keyboard designs may prevent or reduce arm pain or disorders, and probably the mechanism is by reducing awkward arm postures. Previous researchers have put their effort on optimizing the character arrangement of the keyboard by taking into account the co-occurrence frequency of characters in words, typing ergonomics, and word disambiguation effectiveness. This research considers the frequency of appearance of the most used 3000 words in the English language. First, the text Analyzer calculates the frequency of each letter pair. Then, a genetic algorithm is applied to design an ergonomically optimized keyboard to minimize the total distance of finger travel among the selected alphanumeric characters. The results showed that the distance travelled obtained by the proposed keyboard layout is less than that for the QWERTY keyboard in all different types of texts, in which an average of 6.04% improvement was achieved. Therefore, the proposed design can be used for keyboards to reduce time and fatigue.

Keywords: Keyboard design, Systematic layout planning, Genetic algorithm

ÖZ

Teknoloji ilerledikçe iş amaçlı bilgisayar kullananan kişilerinde sayısı da artmaktadır. Bilgisayarlı iş istasyonlarında uygulanan ergonomik tasarımlar, yaşanan kas-iskelet sistemi rahatsızlıklarını azaltmakta ve çalışanların genel iş memnuniyetini artırmaktadır. Farklı şekil ve boyutlara sahip bilgisayarlardan mobil cihazlara kadar çeşitli sistemlerde klavyeler mevcuttur. Klavye boyutu ve şeklinin üst ekstremiteleri etkilediği bilinmektedir. Alternatif klavye tasarımları kol ağrısını veya bozukluklarını önleyebilir veya azaltabilir, ayrıca bu tasarımlar uygunsuz kol duruşlarını azaltmaktır. Literatürde kelimelerdeki karakterlerin bir arada bulunma sıklığı, yazma ergonomisi ve kelime belirsizliğini giderme etkinliğini dikkate alarak klavyenin karakter düzenlemesini optimize etmek için çalışmalar mevcutturr. Bu araştırma, İngilizcede en çok kullanılan 3000 kelimenin görülme sıklığını ele almaktadır. İlk olarak, metin çözümleyici her bir harf çiftinin frekansını hesaplandı. Ardından, seçilen alfasayısal karakterler arasında parmak hareketinin toplam mesafesini en aza indirmek için ergonomik olarak optimize edilmiş bir klavye tasarlamak için genetik bir algoritma uygulandı. Sonuçlar önerilen klavye düzeniyle elde edilen mesafenin tüm farklı metin türlerinde QWERTY klavyeden daha az olduğunu ve ortalama% 6,04'lük bir iyileştirmenin elde edildiğini göstermektedir. Bu nedenle önerilen tasarım, klavyeler için zamanı ve yorgunluğu azaltmak için kullanılabilir.

Anahtar Kelimeler: Klavye tasarımı, Sistematik vaziyet planı, Genetik alogritma

I came to Cyprus in 2007, when I was a young boy with a bachelor degree in industrial engineering. I started my study in master of industrial engineering in 2008 and it was finished in 2011. Then I continued studying PHD of industrial engineering during which I experienced the life full of memories, good and bad, sweet and bitter, love and hate. I found too many friends, some of them like a brother.
During these years the only one who helped me without any expectation was my parents, mother and father. I'm so lucky to have them in my life, I love them forever. A real love without any limitation.

During my studies, I met my advisor, Dr.Orhan. He was my advisor in master degree and then in my Ph.D. degree also. I bothered him a lot, and he was always patient. Now I feel I have a big brother who supports me and helps me anytime. His wife "Dr. Bakiye" and also their sweet baby "Kaya", looks like my family. I'm proud to myself for having them.

.

Dedication to my dear grandparents
May their souls be at peace

A Memory of Covid-19

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Chapter 1

INTRODUCTION

Use of computers has become a necessity for any purposes. The keyboard represents one of the most popular and effective devices to insert, edit, delete and update long chunk of information. Keyboards were firstly introduced more than 100 years ago to support the typists' task.

The character arrangement on a keyboard can affect a person’s comfort and typing performance. Computer keyboard characteristics can affect computer users’ risks for developing upper extremity musculoskeletal disorders (MSDs). Studies have shown that a keyboard’s key activation force, travel distance, force-displacement characteristics, and tactile feedback can affect typing forces, muscle activity, muscle fatigue and discomfort in the upper extremities.

The two most popular keyboards are the QWERTY and Dvorak keyboards. Since the traditional QWERTY layout appeared on the typewriter in 1878, many efforts have been made to improve its inherent inefficiency. Dvorak Simplified Keyboard (DSK) has been very positively evaluated in terms of user performance and learnability however, can be very inefficient when typing in languages other than English, because it was designed using only the English corpus.

Easily entering information into computers has been recognized as a key obstacle to adoption of computers for a variety of uses. Various entering data are used for input data to a device. Voice and handwriting are two methods for entering data but the alphabet keyboard remains one of the best technologies for entering a large variety of information accurately and quickly.

This paper addresses the problem of text entry and comparing the performance potential of alternate layouts for finding the optimal keyboard layout for the English language.

In order to correctly define this problem, the following approach is use: First, an analysis words is proposed, and then systematic layout planning is applied to design a new ergonomic keyboard.

To this aim two specific software is written specially for this research, this software is unique.

First software is called “text analyzer”. It was coded to analyze the words. The analyzer provides the most frequent letter and most common pairs of letters used in a text and second software is called “Travel Distance calculator”. This software calculated travel distance for any sample text depend on different keyboard layout.

Also, a mathematical algorithm applied to find the minimum travel distance according to the objective function. MATLAB software is used to find the minimum travel distance based on heuristic algorithm.

Thus, the main aim of this paper is to propose an overall design process for the keyboard arrangement problem (KAP), which is based on the frequency of letters and create an optimal modeling on a physical keyboard.

Chapter 2

LITERATURE REVIEW

Various types of keyboards, with different shapes and different layouts are in use nowadays. Each of them has various advantages and disadvantages.

The two most popular keyboards are the QWERTY and Dvorak keyboards. The QWERTY keyboard slows down the typing speed and results in unbalance workload for the left and right hands (Korhan and Mackieh, 2010).

The QWERTY keyboard was introduced by Sholes brothers in 1873. It was initially designed in English context and later designed for other language such as French and Germany. This gave rise to the AZERTY and QWERTZ keyboards.

When compared to a random layout, QWERTY keyboard showed that for inexperienced and relativity more experience user, QWERTY is a superior layout. (Gary Capobianco et al., 1999).

Figures 1-5 shows the layout for Dvorak, ABC, Fitaly, Telephone and Just Type keyboard alternatives.

Figure 1: The Dvorak Layout

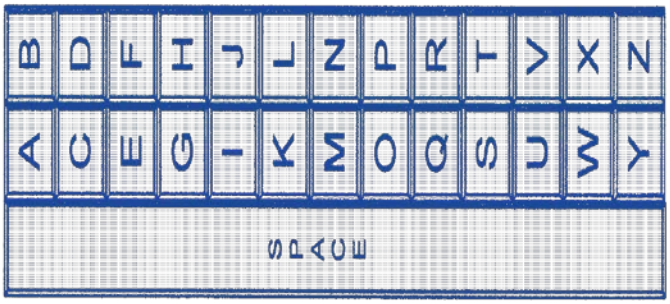

Figure 2: The ABC Layout

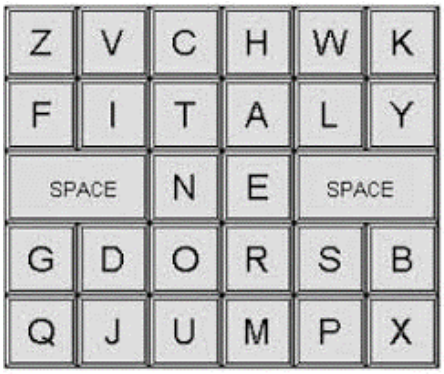

Figure 3: The Fitaly Layout

Figure 4: The Telephone Keyboard Layout

Figure 5: The Just Type Layout

Table1: Typing Speed Rate for Different Keyboard Layouts (Mackenzie, 2003)

	Entry speed (wpm)[a]	
Keyboard layout	Mean	Std. Dev.
Qwerty	20.2	4.9
Dvorak	8.5	2.0
ABC	10.6	1.7
Fitaly	8.2	2.2
Telephone	8.1	1.9
JustType	7.3	1.5
Mean	10.5	±

Mackenzie (2003) showed that typing with QWERTY keyboard was faster than ABC, Dvorak, Fitaly, Just Type and Telephone (table 1).

The Turkish language uses the Turkish Latin alphabet, and a dedicated keyboard layout was designed in 1955 by İhsan Sıtkı Yener.During its design, letter frequencies in the Turkish language were investigated with the aid of Turkish language association. These statistics were then combined with studies on bone and muscle anatomy of the fingers to design the Turkish F-keyboard (Turkish: F klavye) (figure 6). The keyboard provides a balanced distribution of typing effort between the hands: 49% for the left hand and 51% for the right. Despite the greater efficiency of the Turkish F-keyboard however, the modified QWERTY keyboard is the one that is used on most computers in Turkey. The reason for the popularity of QWERTY in Turkey is that they were overwhelmingly imported since the beginning of the 1990s.

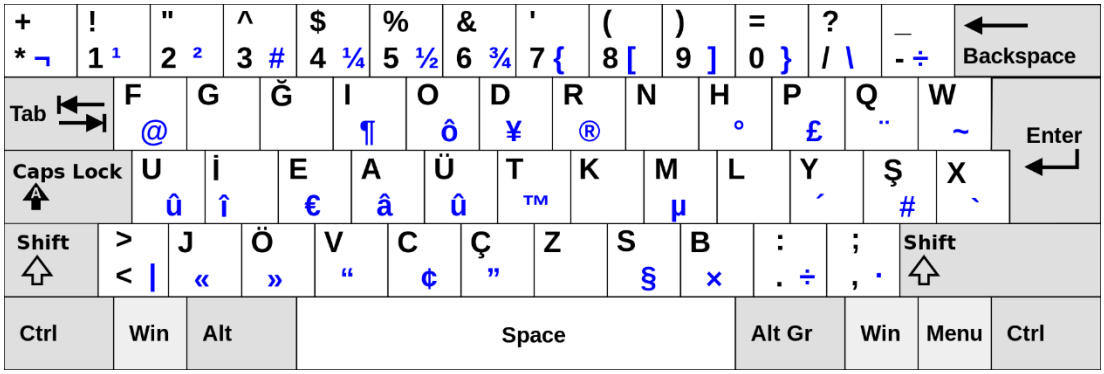

Figure 6: Turkish F Keyboard Layout

Mevlut Serkan Tok et al. did a research for Turkish layout keyboard, they studied two different type of Turkish keyboard as F keyboard and E keyboard. (Analyzing Turkish F and Turkish E keyboard layouts using learning curves). The result showed that there is no significant difference between learning percentage of these two layouts but the completion time of typing a trial passage with the F-layout is significantly lower than the E-layout. The F-layout has also a significantly lower physical demand score, as revealed by the subjective assessments of participants. Based on our user survey data,

they also discuss some possible reasons of F-keyboard's limited prevalence among Turkish users.

Four different methods for inputting data are used by operators. (Shumin Zhai et al., 2015; Ward, Blackwell, & MacKay, 2000)

- Physical keyboard
- Handwriting
- Voice recognition
- Eye control
- Mouse movement

In order to provide an optimal layout, each method has different advantages and disadvantages. It is possible to reduce the size of physical keyboard by using two ways, the first one refers to use smaller key and the second one is using number pads in telephone, it means that each key correspond to multiple letters. Reducing error rate has been the major goal in handwriting recognition also it is very difficult to write legibly at a high speed.

Speech can be one of the best methods for inputting data if the recognize process works correctly, however for some people it is harder to talk and think than type and think. Halverson, Horn, and Karat (1999) showed that the effective speed of text entry by continuous speech recognize was still far lower than that of the keyboard.

One of the disadvantages of mouse movement method refers to the process when operator has to constantly distinguish the dynamically arranged letters. The visual

identification task may limit the eventual performance of text entry with such a method.

A keyboard design should conform to four core objectives: (Marc Oliver Wagner et al., 2010; Jan Eggers et al., 2003)

- Allow one to type a text without tiredness
- Maximize typing speed
- Reduce the number of typing errors
- Allowed a rapid mastery of the touch-typing method

Beside these, ergonomic criteria must be attending to creating a new key board (Chen Liao and Pilsung Choe, 2013)

- Tapping workload distribution
- Hand alternation
- Finger alternation
- Avoidance of big steps
- Hit direction

KAP (Keyboard Arrangement Problem) is known as the best potential arrangement of letters on a keyboard based on ergonomic procedures. Distinctive technique based on using an evaluation function based on a complex set of ergonomic criteria is covering for a new layout. table2 presents recent researches in this regard.

Table 2: KAP Research

Research	Evaluation Function	Algorithm	Target Language
Light and Anderson, 1993	Relative Frequency of letter pair X Travel Time	Simulated annealing	English
Walker, 2003	Penalty points awarded to specific letter pairs	Genetic with two pooled approach	English
Eggers et al., 2003	Six marsan's ergonomic criteria	Ant Colony Optimization	French, Germany, English
Wagner et al., 2003	six marsan's ergonomic criteria	Ant Colony Optimization	French, Germany, English
Deshwai and Deb, 2003	six marsan's ergonomic criteria	Genetic	Hindi
Geottl et al., 2005	Four marsan's ergonomic criteria	Genetic	English
Malas et al., 2008	Relative Frequency of letter pair X Travel Time	Genetic	Arabic

According to Jan Eggers et al., 2003 the algorithm base on ant colony optimization, the new layout keyboard is shown in figure 7.

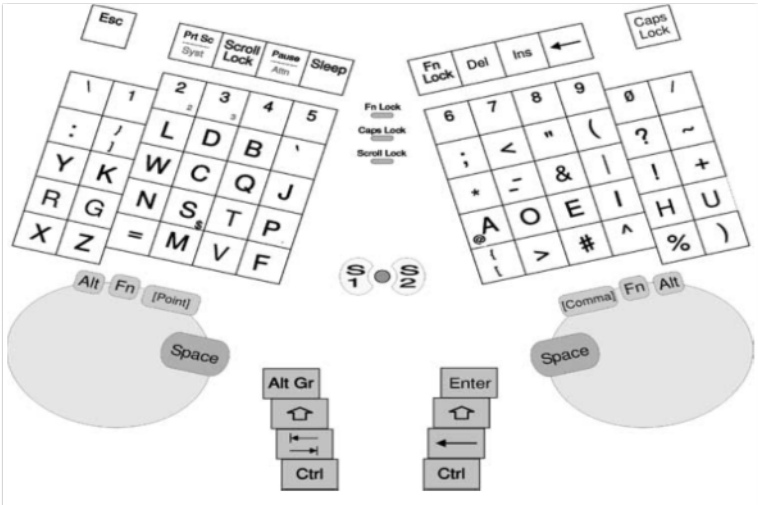

Figure 7: Jan Eggers Keyboard Layout

Gregory Francis, Clarence E. Rash, 2003 researches demonstrate a new approach in designing keyboard. They reveal a program that can quickly build the optimal keyboard layout that minimizes the time required to input a given set of data. This approach makes it possible to create different keyboard designs for different specialized uses of keyboards and or for different individuals.

The importance of an ergonomic design is reducing the travel distance. Supposed that a keyboard design saves 1 cm of finger travel per letter (hens about 5 cm per word); if a person type on average 100 words per day (email, texting, etc.), then 100 words* 5 cm*365 day is equal 1.825 kilometers of travel will be saved per person per year. Xiaojun Bi et al 2012 made and studies for English, French, Spanish, Germany and Chinese. Reducing its stylus travel distance to about half of QWERTY's for all of the five languages.

In comparison to QWERTY's 3.31, 3.51, 3.7, 3.26, and 3.85 keys of movement for English, French, Spanish, German, and Chinese, respectively, the optimized

multilingual layout has an average travel distance of 1.88, 1.86, 1.91, 1.77, and 1.68 keys, correspondingly.

Zhai et al. (2011) studied performance optimization of virtual keyboards. To this end, two quantitative design methods were proposed to find best layouts for virtual keyboard. The first technique was simulating the dynamics of a keyboards and the second one was a metropolis random walk algorithm.

Dunlop and Levine (2012) developed a multidimensional Pareto optimization algorithm to optimize keyboard layouts. In this study, three objectives include speed, familiarity with QWERTY and improved spell-checking ability is considered.

Bi et al. (2012) studied multilingual touch screen keyboard design and optimization. To this end, first, an optimum layout is developed for five languages so that travel distance reduced.

Oulasvirta et al. (2013) proposed the KALQ layout, for efficient two-thumb typing. This kind of layout is proposed to reduce thumb travel distance between thumbs.

Bi et al. (2013) proposed a complementary method to evaluate touchscreen keyboard correction and recognition algorithm. An evaluation tool is developed in order to show the proposed approach.

Vertanen and Kristensson (2014) evaluate complementing text entry with a composition task. They found that participants could consistently and rapidly invent high quality and creative compositions with only modest reductions in entry rates.

Bi et al. (2014) developed a multi-objective optimization of touchscreen keyboard. They show that it is possible to optimize a keyboard algorithm for both correction and completion. They demonstrate the effectiveness of their proposed method.

Karrenbauer and Oulasvirta (2014) developed a mathematical model to optimize keyboard layout. To this end, an integer programming model is proposed for letter assignment problem and solved by branch and bound approach.

Hsiao et al. (2014) design new linear QWERTY keyboards for small devices. They developed four miniature keyboards which varied from conventional one in terms of their layout. Then the proposed layouts were evaluated based on input speed, accuracy, comfort, likability and learnability. The results show that new approaches have better performance than conventional keyboards.

Iseri and Eksioglu (2015) investigated digraph costs for keyboard layout optimization. They introduced a systematic methodology to develop ergonomic and optimal keyboard layouts. The study also studied the effects of column, row, hand and period on digraph-tapping rate.

Smith et al. (2015) studied touchscreen keyboard layouts for gesture typing. They developed several optimizations methodologies while maintaining some familiarity with QWERTY by using the same layout geometry and only changing the letter placements. In this study, speed, gesture recognition accuracy and similarity with QWERTY have considered as objectives.

Yang and Mali (2016) studied keyboard layout problem to reduce finger travel distance. They developed a met heuristic simulated annealing algorithm to modify keyboard layouts. Results show that the proposed method is able to improve keyboard layouts and outperform the best one compared with approaches reported in literature.

Bi and Zhai (2016) proposed IJQWERTY layout on which position of I and J were swapped. This method improves the performance of gesture typing compared with QWERTY format.

Conway and Sangaline (2017) present a monte carlo simulation for evaluating keyboard layouts. They develop a new approach to quantifying the frequency of gesture input errors by modeling incomplete user input. This new methodology reconstructs words from gestures on arbitrary keyboard layouts. Donda framework which is accessible freely is also provided that authorize these techniques to evaluate a wide spectrum of possible keyboards and input methods.

Yi et al. (2017) investigated the performances users when typing on tiny QWERTY keyboards. They found that the simple Bayesian algorithm works well for text on tiny keyboards. The results show that the most acceptable size of keyboards on smart watches is between 3 and 4 cm. Furthermore, keyboard size effects on finger posture, typing and user performance.

Noah et al. (2017) evaluated touchscreen versus keyboard/mouse interaction for large screen process control displays. They measured different criteria such as interaction time, workload, performance and experience. Results show that touchscreen was significantly faster in data entry and slower in detection and navigation.

Kang and Shin (2017) studied effects of touch target location on performance. They also tried to assess physical demands of computer touchscreen use. Results show that if targets place in the lower area of the display the muscle activity will decrease up to about 40 percent. Furthermore, users can complete a tap gesture up to about 30 percent faster for targets in lower area.

2.1 Gap Analysis

In some previous research, they tried to reduce the musculoskeletal disorder by making physical changes to the keyboard shape, in others, the aim was to speed up typing by changing the keyboard layout.

In this research with changing the location of the letter on keyboard a new layout was designed that improved type speed and reduce muscle disorder. Millions of English words and their importance and weight of combination's letter were examined by using Text Analyzer's special software and then with using a unique mathematical algorithm, a new keyboard layout was designed based on minimizing the travel distance.

For the first time the software was designed as Travel Distance Calculator to be able to calculate the amount of distance in different keyboard designs for different texts.

Finally, using this software, we were able to compare the improvement of the distance traveled for the proposed keyboard with the QWERTY keyboard and measure the improvement.

Chapter 3

METHODS

Many researches have been done to design a new layout for keyboard, each of them attends to various algorithms and use different methods.

Figure 8 illustrates the procedure of the proposed method. As shown in Figure 8, first, the 3,000 most common words are extracted. Next, the numbers of each pair of letters that come together are calculated by the Text Analyzer software. Then, a mathematical programming model for the keyboard layout and a metaheuristic algorithm are developed to solve the problem. Finally, the results obtained from the proposed method are compared with the tablet QWERTY keyboard.

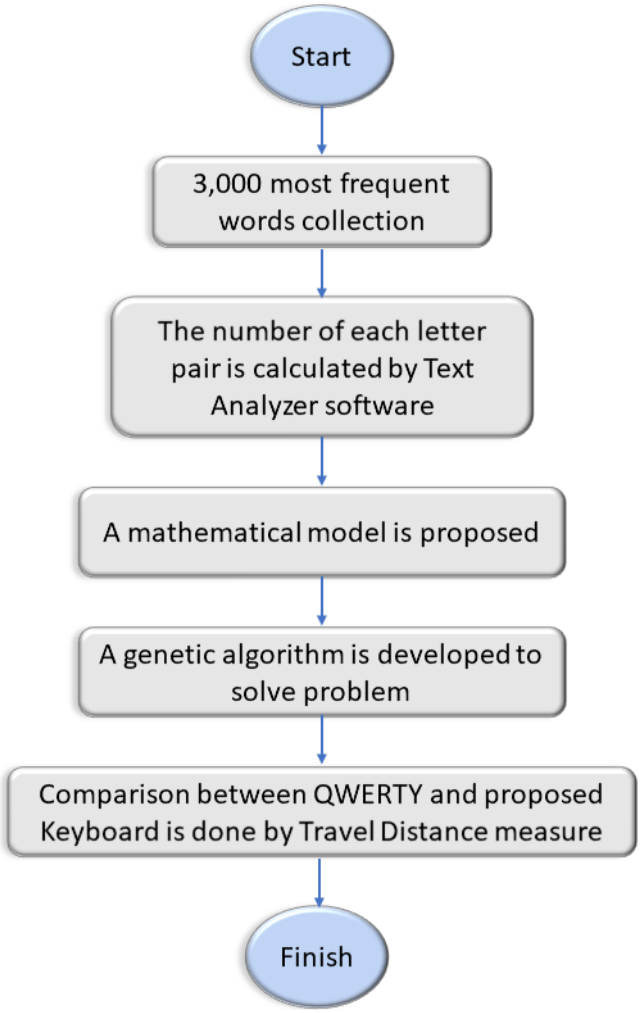

Figure 8: The Proposed Methodology

However, the basement of many studies is the popularity of letter frequency, investigating the popularity of the pair combination of each letter needs more attention. Accordingly, the present study focuses on the frequency of both the pair combination of each letter and popularity of each letter to design optimal layout.

The program is written based on C-Sharp language. This software is able to analyze words in different languages. To minimize finger movement on a virtual keyboard, two factors must be taken into account. One is the transitional frequency from one letter to another in a given language and the other is the relative distances between keys. The goal should be to arrange the letters in a way that the statistical total travel

distance is the shortest when tapping on such a keyboard. This means that the most frequent keys should be located in the center of the keyboard and the frequently connected letters should be closer to each other than the less frequently connected letters.

3.1 Introduce of Text Analyzer

The interface of program shown in figure 9, the program is written by C#. It is called Text Analyzer. The properties of Text Analyzer are as follow:

- Show the frequency of each letter
- Show the frequency of combination alphabet
- Exclude or include punctuation
- Exclude or include Spaces
- Sensitive on capital letter
- Use any languages

Data can be typed or past from any text format, even directly from a webpage. The result can be export to any Microsoft office program directly.

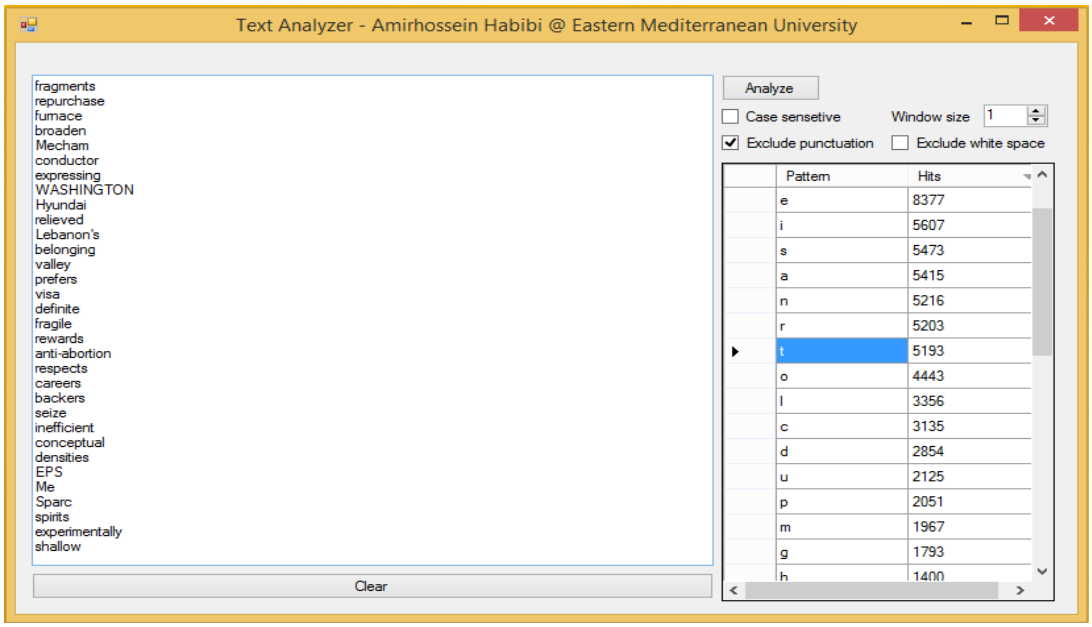

Figure 9: Text Analyzer Interface

3.2 Word Selection Mechanism

In this section, mechanism of word selection is explained in order to find the best keyboard layout. For this purpose, The Longman Communication 3000 which is listed 3000 most frequent words in both spoken and written English, based on statistical analysis of the 390 million words contained in the Longman Corpus Network, is used. (https://www.lextutor.ca/freq/lists_download/longman_3000_list.pdf). The Longman Communication 3000 represents the core of the English language and shows students of English which words are the most important for them to learn and study in order to communicate effectively in both speech and writing.

Analysis of the Longman Corpus Network shows that these 3000 most frequent words in spoken and written English account for 86% of the language. This means that by knowing this list of words, a learner of English is in a position to understand 86% or more of what he or she reads.

To ensure that users have access to the appropriate information, the Longman Dictionary of Contemporary English marks all the words that are in the Longman Communication 3000 in red accompanied by special symbols: W1, W2, and W3 for words that are in the top 1000, 2000 and 3000 most frequent words in written English and S1, S2, and S3 for the top 1000, 2000 and 3000 most frequent words in spoken English. In this study, the written English is considered because the goal is layout planning for keyboard. Take for example the noun ability. It is marked as W1 – one of the top 1000 words of written English. The list of 3000 words is reported in Appendix (A). It is noted that the word which is marked by W1, W2, and W3 is considered 3, 2, and one times, respectively.

3.3 Word Analyzing

In this section, these 3000 words are analyzed. To do this end, Text Analyzer software is generated by C# language programming that is shown in Figure 10. The Program code is shown in appendix C.

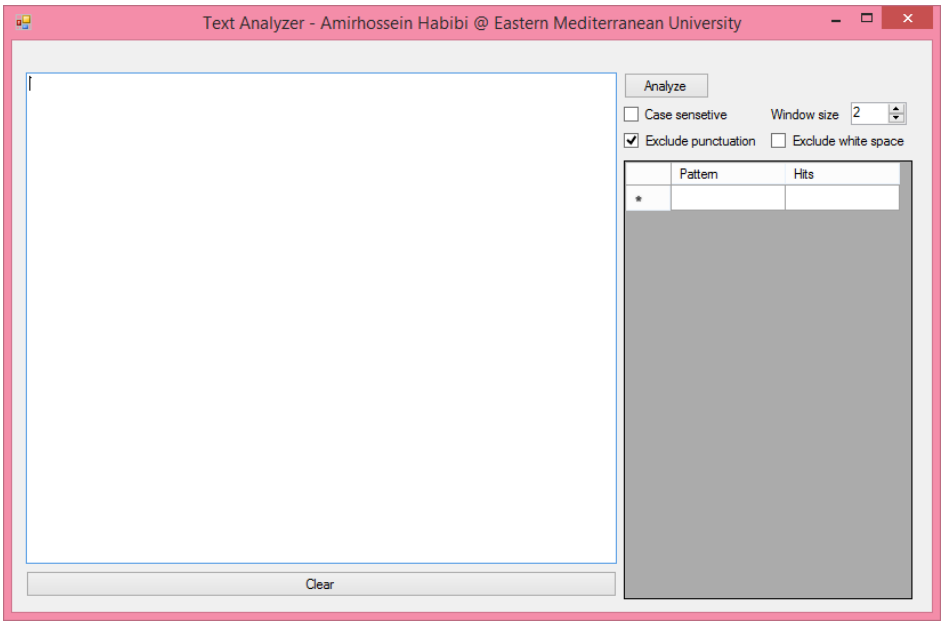

Figure 10: Text Analyzer Software

The software flowchart is shown in figure 11.

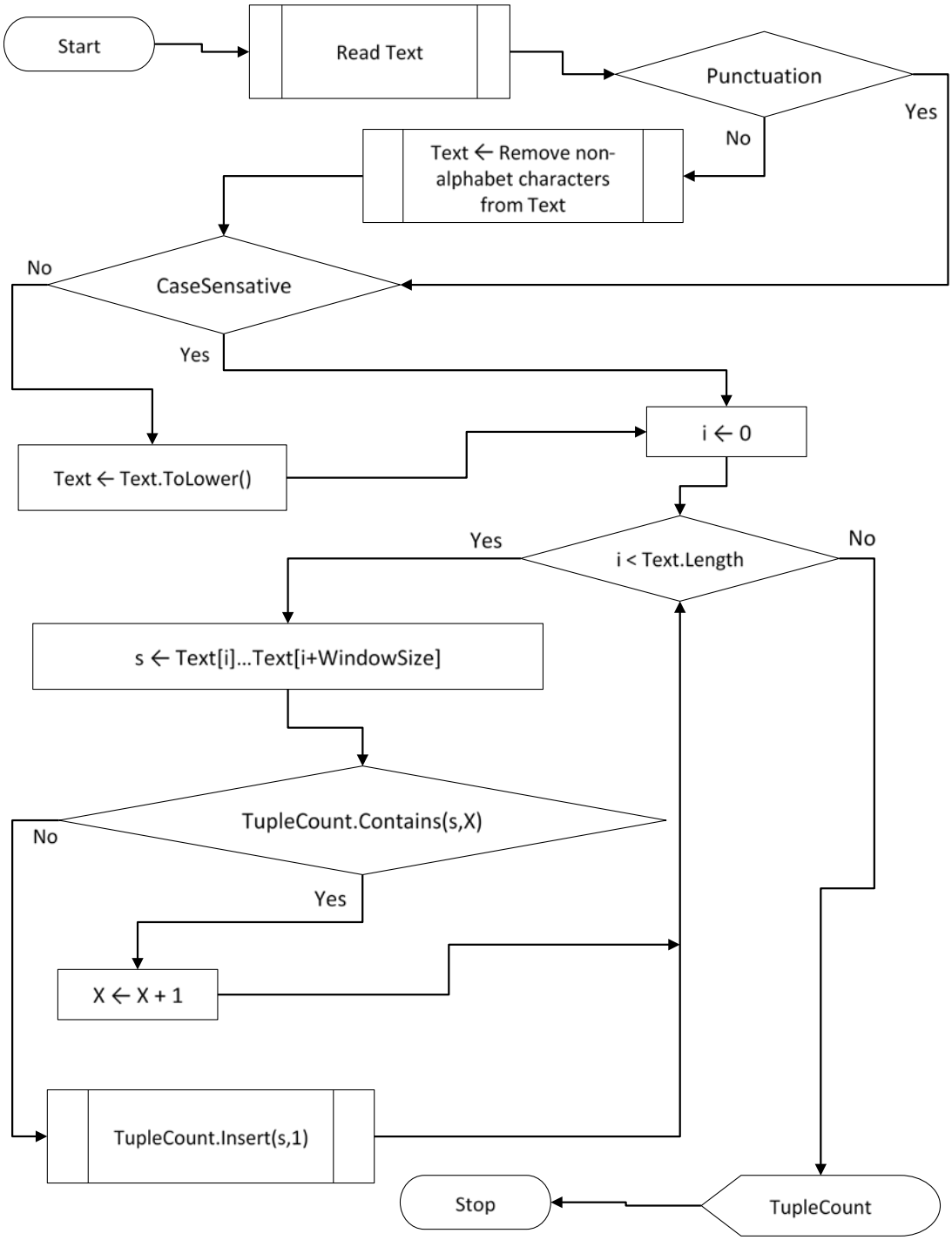

Figure 11: Text Analyzer Flowchart

As shown in figure 10, this software is able to count number of each letter separately as well as number of two or more combination of letters. This feature is controlled by

Window size option. Case sensitive option shows difference between capital and lowercase letters. Even, punctuation marks such as comma, dot, question marks, etc. can be considered. For this purpose, it is needed all words are copied in blank page as shown in figure 12.

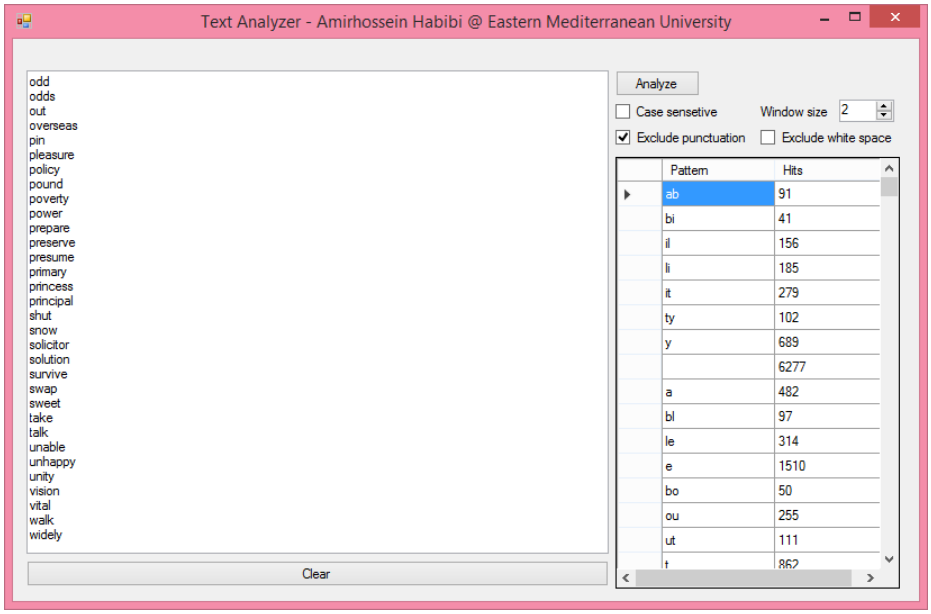

Figure 12: Text Analyzer Software Mechanism

It, firstly, analyze the frequency of each letter then the pair combination of letter is analyzed. Result for each alphabet shown in table 3.

Table 3: Frequency of Each Letter

Letter	Frequency
a	3104
b	506
c	1765
d	1205
e	5177
f	631
g	796
h	995
i	2867
j	36
k	309
l	1957
m	1048
n	2700
o	2505
p	1404
q	86
r	3167
s	2317
t	3079
u	1306
v	534
w	413
x	144
y	818
z	39

As shown in figure 12, the number of times that letter (b) comes after letter (a) is 91. It is remarkable that this software is able to use for every language, thus this layout designing mechanism can be developed for all language. In the same way, two combinations of all letters are calculated and shown in table 4.

Table 4: Two Combinations of Letters

AA	0	BA	84	CA	142	DA	70	EA	356	FA	79	GA	59	HA	157	IA	85
AB	91	BB	4	CB	0	DB	4	EB	14	FB	0	GB	0	HB	2	IB	33
AC	207	BC	0	CC	44	DC	0	EC	245	FC	0	GC	0	HC	0	IC	254
AD	128	BD	0	CD	0	DD	31	ED	131	FD	0	GD	0	HD	0	ID	130
AE	0	BE	72	CE	320	DE	308	EE	130	FE	96	GE	161	HE	213	IE	112
AF	27	BF	0	CF	0	DF	2	EF	80	FF	63	GF	0	HF	0	IF	53
AG	103	BG	0	CG	0	DG	12	EG	48	FG	0	GG	13	HG	0	IG	119
AH	2	BH	0	CH	206	DH	1	EH	8	FH	0	GH	92	HH	0	IH	0
AI	161	BI	41	CI	124	DI	156	EI	32	FI	81	GI	50	HI	130	II	0
AJ	6	BJ	11	CJ	0	DJ	1	EJ	2	FJ	0	GJ	0	HJ	0	IJ	0
AK	39	BK	0	CK	100	DK	0	EK	8	FK	0	GK	0	HK	0	IK	20
AL	426	BL	97	CL	62	DL	18	EL	261	FL	16	GL	17	HL	6	IL	156
AM	90	BM	3	CM	0	DM	12	EM	161	FM	0	GM	0	HM	7	IM	113
AN	381	BN	0	CN	0	DN	2	EN	559	FN	0	GN	39	HN	8	IN	594
AO	2	BO	50	CO	304	DO	44	EO	14	FO	93	GO	17	HO	167	IO	367
AP	110	BP	0	CP	0	DP	2	EP	102	FP	0	GP	0	HP	0	IP	46
AQ	0	BQ	0	CQ	2	DQ	0	EQ	28	FQ	0	GQ	0	HQ	0	IQ	5
AR	426	BR	41	CR	86	DR	40	ER	707	FR	51	GR	89	HR	22	IR	119
AS	216	BS	16	CS	6	DS	12	ES	322	FS	0	GS	3	HS	2	IS	240
AT	469	BT	4	CT	219	DT	0	ET	171	FT	25	GT	7	HT	55	IT	279
AU	28	BU	52	CU	77	DU	68	EU	4	FU	72	GU	49	HU	28	IU	0
AV	44	BV	4	CV	0	DV	18	EV	102	FV	0	GV	0	HV	0	IV	106
AW	27	BW	0	CW	0	DW	2	EW	30	FW	2	GW	0	HW	2	IW	0
AX	9	BX	0	CX	0	DX	0	EX	130	FX	0	GX	0	HX	0	IX	2
AY	77	BY	10	CY	17	DY	25	EY	16	FY	9	GY	10	HY	11	IY	0
AZ	4	BZ	0	CZ	0	DZ	0	EZ	6	FZ	0	GZ	0	HZ	0	IZ	26

JA	0	KA	4	LA	181	MA	213	NA	138	OA	24	PA	174	QA	0	RA	314
JB	0	KB	0	LB	1	MB	23	NB	2	OB	24	PB	2	QB	0	RB	7
JC	0	KC	0	LC	8	MC	0	NC	202	OC	70	PC	0	QC	0	RC	57
JD	0	KD	0	LD	43	MD	0	ND	221	OD	50	PD	0	QD	0	RD	87
JE	20	KE	72	LE	314	ME	290	NE	237	OE	8	PE	242	QE	0	RE	832
JF	0	KF	2	LF	19	MF	1	NF	36	OF	49	PF	2	QF	0	RF	9
JG	0	KG	2	LG	0	MG	0	NG	240	OG	30	PG	0	QG	0	RG	48
JH	0	KH	0	LH	0	MH	0	NH	2	OH	1	PH	40	QH	0	RH	7
JI	0	KI	26	LI	185	MI	114	NI	118	OI	30	PI	60	QI	0	RI	283
JJ	0	KJ	0	LJ	0	MJ	0	NJ	9	OJ	3	PJ	0	QJ	0	RJ	4
JK	0	KK	0	LK	9	MK	0	NK	30	OK	23	PK	0	QK	0	RK	32
JL	0	KL	7	LL	223	ML	0	NL	21	OL	118	PL	122	QL	0	RL	28
JM	0	KM	0	LM	4	MM	42	NM	12	OM	157	PM	5	QM	0	RM	74
JN	0	KN	18	LN	4	MN	1	NN	31	ON	633	PN	0	QN	0	RN	60
JO	11	KO	2	LO	133	MO	99	NO	117	OO	77	PO	166	QO	0	RO	277
JP	0	KP	0	LP	9	MP	124	NP	2	OP	114	PP	70	QP	0	RP	26
JQ	0	KQ	0	LQ	0	MQ	0	NQ	2	OQ	0	PQ	0	QQ	0	RQ	0
JR	0	KR	0	LR	3	MR	0	NR	0	OR	345	PR	269	QR	0	RR	68
JS	0	KS	4	LS	11	MS	9	NS	107	OS	98	PS	14	QS	0	RS	76

JT	0	KT	0	LT	46	MT	0	NT	463	OT	117	PT	44	QT	0	RT	163
JU	5	KU	0	LU	36	MU	34	NU	30	OU	255	PU	62	QU	86	RU	62
JV	0	KV	0	LV	18	MV	0	NV	32	OV	78	PV	0	QV	0	RV	31
JW	0	KW	2	LW	5	MW	0	NW	2	OW	112	PW	0	QW	0	RW	12
JX	0	KX	0	LX	0	MX	0	NX	2	OX	1	PX	0	QX	0	RX	0
JY	0	KY	7	LY	271	MY	16	NY	33	OY	28	PY	14	QY	0	RY	120
JZ	0	KZ	0	LZ	0	MZ	0	NZ	0	OZ	1	PZ	0	QZ	0	RZ	0

SA	65	TA	224	UA	71	VA	54	WA	105	XA	13	YA	5	ZA	4
SB	3	TB	2	UB	46	VB	0	WB	2	XB	0	YB	6	ZB	0
SC	59	TC	26	UC	68	VC	0	WC	0	XC	17	YC	5	ZC	0
SD	0	TD	0	UD	43	VD	2	WD	2	XD	0	YD	0	ZD	0
SE	350	TE	499	UE	71	VE	310	WE	76	XE	7	YE	28	ZE	29
SF	15	TF	4	UF	7	VF	0	WF	3	XF	0	YF	1	ZF	0
SG	2	TG	0	UG	55	VG	0	WG	0	XG	0	YG	0	ZG	0
SH	128	TH	232	UH	0	VH	0	WH	48	XH	2	YH	1	ZH	0
SI	269	TI	517	UI	59	VI	96	WI	45	XI	16	YI	2	ZI	2
SJ	0	TJ	0	UJ	0	VJ	0	WJ	0	XJ	0	YJ	0	ZJ	0
SK	23	TK	0	UK	0	VK	0	WK	1	XK	0	YK	0	ZK	0
SL	33	TL	43	UL	114	VL	0	WL	12	XL	0	YL	0	ZL	0
SM	24	TM	16	UM	53	VM	0	WM	0	XM	0	YM	8	ZM	0
SN	5	TN	8	UN	178	VN	0	WN	23	XN	0	YN	0	ZN	0
SO	147	TO	127	UO	7	VO	23	WO	18	XO	0	YO	26	ZO	0
SP	111	TP	0	UP	40	VP	0	WP	0	XP	48	YP	5	ZP	0
SQ	8	TQ	0	UQ	0	VQ	0	WQ	0	XQ	0	YQ	0	ZQ	0
SR	1	TR	215	UR	220	VR	0	WR	0	XR	0	YR	2	ZR	0
SS	194	TS	13	US	152	VS	0	WS	2	XS	0	YS	26	ZS	0
ST	470	TT	65	UT	111	VT	0	WT	3	XT	29	YT	8	ZT	0
SU	150	TU	114	UU	0	VU	2	WU	0	XU	2	YU	0	ZU	0
SV	0	TV	2	UV	0	VV	0	WV	0	XV	0	YV	0	ZV	0
SW	19	TW	8	UW	0	VW	0	WW	0	XW	0	YW	5	ZW	0
SX	0	TX	0	UX	0	VX	0	WX	0	XX	0	YX	0	ZX	0
SY	17	TY	102	UY	5	VY	3	WY	0	XY	0	YY	0	ZY	2
SZ	0	TZ	0	UZ	0	VZ	0	WZ	0	XZ	0	YZ	0	ZZ	2

According to Table 4, paired comparison matrix of letters is shown in Table 5. This matrix has 26 row and column (A to Z). The number of times that each word comes after another one is simply obtained by table 5.

Table 5: Paired Comparison Matrix of Letters

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
A	0	84	142	70	356	79	59	157	85	0	4	181	213	138	24	174	0	314	65	224	71	54	105	13	5	4
B	91	4	0	4	14	0	0	2	33	0	0	1	23	2	24	2	0	7	3	2	46	0	2	0	6	0
C	207	0	44	0	245	0	0	0	254	0	0	8	0	202	70	0	0	57	59	26	68	0	0	17	5	0
D	128	0	0	31	131	0	0	0	130	0	0	43	0	221	50	0	0	87	0	0	43	2	2	0	0	0
E	0	72	320	308	130	96	161	213	112	20	72	314	290	237	8	242	0	832	350	499	71	310	76	7	28	29
F	27	0	0	2	80	63	0	0	53	0	2	19	1	36	49	2	0	9	15	4	7	0	3	0	1	0
G	103	0	0	12	48	0	13	0	119	0	2	0	0	240	30	0	0	48	2	0	55	0	0	0	0	0
H	2	0	206	1	8	0	92	0	0	0	0	0	0	2	1	40	0	7	128	232	0	0	48	2	1	0
I	161	41	124	156	32	81	50	130	0	0	26	185	114	118	30	60	0	283	269	517	59	96	45	16	2	2
J	6	11	0	1	2	0	0	0	0	0	0	0	0	9	3	0	0	4	0	0	0	0	0	0	0	0
K	39	0	100	0	8	0	0	0	20	0	0	9	0	30	23	0	0	32	23	0	0	0	1	0	0	0
L	426	97	62	18	261	16	17	6	156	0	7	223	0	21	118	122	0	28	33	43	114	0	12	0	0	0
M	90	3	0	12	161	0	0	7	113	0	0	4	42	12	157	5	0	74	24	16	53	0	0	0	8	0
N	381	0	0	2	559	0	39	8	594	0	18	4	1	31	633	0	0	60	5	8	178	0	23	0	0	0
O	2	50	304	44	14	93	17	167	367	11	2	133	99	117	77	166	0	277	147	127	7	23	18	0	26	0
P	110	0	0	2	102	0	0	0	46	0	0	9	124	2	114	70	0	26	111	0	40	0	0	48	5	0
Q	0	0	2	0	28	0	0	0	5	0	0	0	0	2	0	0	0	0	8	0	0	0	0	0	0	0
R	426	41	86	40	707	51	89	22	119	0	0	3	0	0	345	269	0	68	1	215	220	0	0	0	2	0
S	216	16	6	12	322	0	3	2	240	0	4	11	9	107	98	14	0	76	194	13	152	0	2	0	26	0
T	469	4	219	0	171	25	7	55	279	0	0	46	0	463	117	44	0	163	470	65	111	0	3	29	8	0
U	28	52	77	68	4	72	49	28	0	5	0	36	34	30	255	62	86	62	150	114	0	2	0	2	0	0
V	44	4	0	18	102	0	0	0	106	0	0	18	0	32	78	0	0	31	0	2	0	0	0	0	0	0
W	27	0	0	2	30	2	0	2	0	0	2	5	0	2	112	0	0	12	19	8	0	0	0	0	5	0
X	9	0	0	0	130	0	0	0	2	0	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0
Y	77	10	17	25	16	9	10	11	0	0	7	271	16	33	28	14	0	120	17	102	5	3	0	0	0	2
Z	4	0	0	0	6	0	0	0	26	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	2

The matrix will be used in part 3.4 as weight of each combination (Wi,j). Wi,j is the importance rate between letter I and letter J, that it will be used in objective function. For example, WD, E means the rate between letter D and letter E that it is equal 131. Distance between each two keys will be multiplied to their importance (rate), that rate will be come from table 5 for each combination.

3.4 Proposed Model Formulation

In this section, mathematical programming model to design keyboard layout is presented.

Using the dual combinations from table 5, a mathematical programming model to design a keyboard layout is presented. Considering I, J, and K as the alias sets of keyboard letters, the X-axis and Y-axis coordination of each letter such as k (k∈ K) are shown as a_k and b_k, respectively. The model optimizes the existing (old) system by properly assigning each X-axis and Y-axis coordinate to the set of keyboard letters. figure 13 represents this procedure schematically. As is illustrated in figure 13, (2,2) represents the X-axis and Y-axis coordinates of the letter B in the existing system that is shown by a_B and b_B. The model determines that in the optimal case, the coordinates of letter B, shown by x_B and y_B, should be changed to (1,2). This means that the existing system shows the potential coordinates of letters, and in the next step, the model assigns the coordinates to the letters.

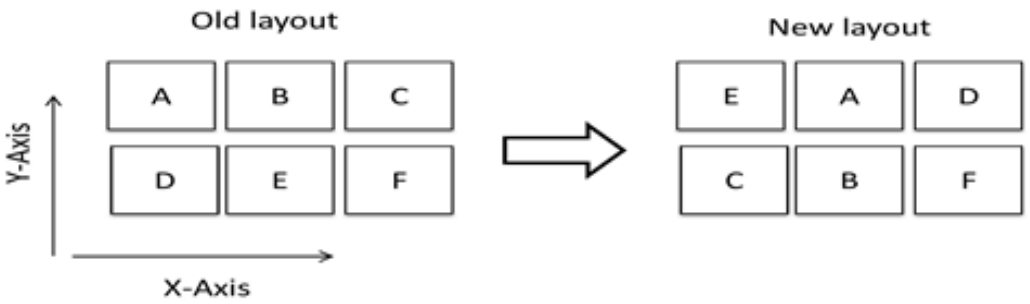

Figure 13: The Procedure Applied by the Mathematical Model

Since the new layout will be based on the X-axis and Y-axis coordinates of the existing system, the mathematical model assigns just one potential X-axis coordinate (such as the kth coordinate) to each letter (such as i) by introducing a binary variable called $n_{i,k}$, which is equal to 1 only if the kth coordinate of the X-axis is assigned to i. The same mechanism is repeated by introducing a binary variable called $m_{i,k}$ for determining the Y-axis coordinate of each letter i.

Sets:

i, j, and k: set of keyboard letters

Parameters:

$w_{i,j}$: the importance rate between letter I and letter j

a_k: the X coordinate of kth key in the existing system

b_k: the Y coordinate of kth key in the existing system

Decision Variables:

x_i: the X coordinate of ith letter in the new system

y_i: the Y coordinate of ith letter in the new system

$n_{i,k}$: $\begin{cases} 1 \; if \; the \; k^{th} \; key \; on \; X \; axis \; is \; assigned \; to \; the \; i^{th} \; letter \\ 0 \quad otherwise \end{cases}$

$m_{i,k}$: $\begin{cases} 1 \ if \ the \ k^{th} \ key \ on \ Y \ axis \ is \ assigned \ to \ the \ i^{th} \ letter \\ 0 \quad otherwise \end{cases}$

Model:

$$Min \sum_i \sum_j w_{i,j}\left(|x_i - x_j| + |y_i - y_j|\right) \tag{3-1}$$

Subject to:

$$x_i = \sum_k n_{i,k} a_k \qquad \forall\, i \tag{3-2}$$

$$y_i = \sum_k m_{i,k} b_k \qquad \forall\, i \tag{3-3}$$

$$\sum_k n_{i,k} = 1 \qquad \forall\, i \tag{3-4}$$

$$\sum_k m_{i,k} = 1$$

$$\sum_i n_{i,k} = 1 \qquad \forall\, k \tag{3-5}$$

$$\sum_i m_{i,k} = 1$$

The objective function minimizes the weighted distance between the keys. For each letter, constraints 3-2 and 3-3 assign a specific location on X and Y axis. Constraint 3-4 guarantees that each letter is assigned to a unique location while constraint 3-5 assures that each location is assigned to a unique letter. As this problem is Np-hard, to solve it in large scale a meta heuristic algorithm is developed.

3.5 Proposed Genetic Algorithm

As mentioned above, this study tries to design keyboard optimally. To do this end, travel distance between letters in keyboard to type the text must be minimized. In order to calculate the travel distance, two components are needed. Significance between each two letters that is obtained from table 5 and distance between each two letters in common keyboard. For example, letter (s) next to letter (a) is one-unit distance or letter

(d) has 2 units distance from letter (a). These two components are imported to proposed model which is coded in MATLAB software.

In order to improve common keyboard, since we have 26 keys and 26 designed space on keyboard the total possible different layout for the keyboard is 26 factorials (26!). Each possible layout must be study by objective function and find the best layout, as the total possible layout is huge (26!) it is not possible to find and check all of the possibility, then a genetic meta-heuristic algorithm is developed. In the following, genetic algorithm encoding is illustrated.We have 26 keys and 26 designed space on the keyboard. The solution encoding consists of a 26-element vector. The i^{th} element determines which letter would be positioned in the i^{th} space on the keyboard. It is obvious that the distance between each pair of the spaces on the keyboard is known. The frequency of using two letters consequently is used as the weight required for calculating the total distance. In the following example as shown in figure 14, the letter "B" is positioned in the first space, "E" in the second one and so forth. The calculation of the corresponding fitness value is straightforward.

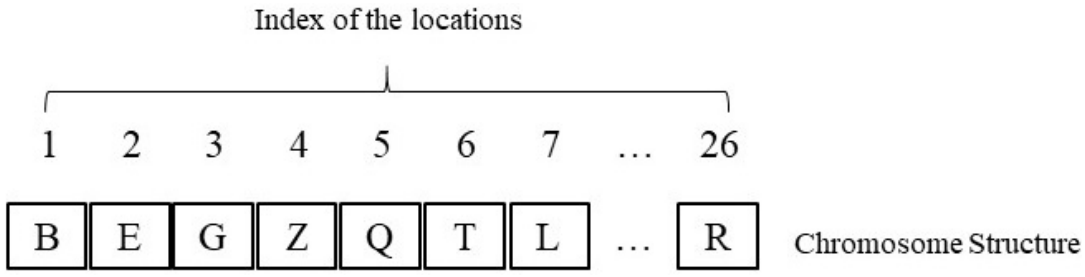

Figure 14: Solution Encoding

As mentioned before, there are two import data including importance between each pair letter and distance between them. figure 15 shows how the required data are imported.

According to this pseudo code, w is obtained from table 5 which shows the frequency of each pair of letters. Furthermore, x and y indicate the longitudinal and transverse coordinates of each letter. Furthermore, d shows the orthogonal distance between each pair of letters. Distance between each two letters is calculated based on the distance between the centers of two letter. Tables 5 and 6 are reported w and d matrix, respectively.

```
function model=CreateModel()
    w=importdata('w.mat');

    n=size(w,1);

    x=importdata('x.mat');
    y=importdata('y.mat');

    m=numel(x);
    d=importdata('d.mat');

    model.n=n;
    model.m=m;
    model.w=w;
    model.x=x;
    model.y=y;
    model.d=d;
 end
```

Figure 15: Import Data

Table 6: Orthogonal Distance Between Two Letters (D Matrix)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
A	0	5	4	2	3	3	4	5	7	6	7	8	7	6	8	9	1	3	1	4	6	4	1	2	5	1
B	5	0	2	3	4	2	1	1	3	2	3	4	2	1	4	6	6	3	4	2	2	1	5	3	2	4
C	4	2	0	1	2	1	2	3	5	4	5	6	4	3	6	7	4	2	2	2	4	1	3	1	3	2
D	2	3	1	0	1	1	2	3	5	4	5	6	5	4	6	7	3	1	1	2	4	2	2	1	3	2
E	3	4	2	1	0	2	3	4	5	5	6	7	6	5	6	7	3	1	1	2	4	2	2	1	3	2
F	3	2	1	1	2	0	1	2	4	3	4	5	4	3	5	6	4	1	2	1	3	1	3	2	2	3
G	4	1	2	2	3	1	0	1	3	2	3	4	3	2	4	5	5	2	3	1	2	1	4	3	1	4
H	5	1	3	3	4	2	1	0	2	1	2	3	2	1	3	4	6	3	4	2	1	2	5	4	1	5
I	7	3	5	5	5	4	3	2	0	1	1	2	2	3	1	2	7	4	6	3	1	5	6	6	2	7
J	6	2	4	4	5	3	2	1	1	0	1	2	1	1	2	3	7	4	5	3	1	3	6	5	2	6
K	7	3	5	5	6	4	3	2	1	1	0	1	1	2	1	2	8	5	6	4	2	4	7	6	3	7
L	8	4	6	6	7	5	4	3	2	2	1	0	2	3	1	1	9	6	7	5	3	5	8	7	4	8
M	7	2	4	5	6	4	3	2	2	1	1	2	0	1	2	3	8	5	6	4	2	3	7	5	3	6
N	6	1	3	4	5	3	2	1	3	1	2	3	1	0	3	4	7	4	5	3	2	2	6	4	2	5
O	8	4	6	6	6	5	4	3	1	2	1	1	2	3	0	1	8	5	7	4	3	6	7	9	3	9
P	9	6	7	7	7	6	5	4	2	3	2	1	3	4	1	0	9	6	8	4	3	7	8	9	4	9
Q	1	6	4	3	3	4	5	6	7	7	8	9	8	7	8	9	0	3	2	4	6	5	1	3	5	2
R	3	3	2	1	1	1	2	3	4	4	5	6	5	4	5	6	3	0	2	1	3	2	2	3	2	3
S	1	4	2	1	1	2	3	4	6	5	6	7	6	5	7	8	2	2	0	3	5	3	1	1	4	1
T	4	2	2	2	2	1	1	2	3	3	4	5	4	3	4	4	4	1	3	0	2	2	3	4	1	4
U	6	2	4	4	4	3	2	1	1	1	2	3	2	2	3	3	6	3	5	2	0	4	5	5	1	7
V	4	1	1	2	2	1	1	2	5	3	4	5	3	2	6	7	5	2	3	2	4	0	4	2	2	3
W	1	5	3	2	2	3	4	5	6	6	7	8	7	6	7	8	1	2	1	3	5	4	0	2	4	2
X	2	3	1	1	1	2	3	4	6	5	6	7	5	4	9	9	3	3	1	4	5	2	2	0	4	1
Y	5	2	3	3	3	2	1	1	2	2	3	4	3	2	3	4	5	2	4	1	1	2	4	4	0	5
Z	1	4	2	2	2	3	4	5	7	6	7	8	6	5	9	9	2	3	1	4	7	3	2	1	5	0

According to these components, the proposed genetic algorithm tries to find an optimal keyboard layout so that the travel distance between letters is minimized. Based on above explanation, procedure of calculating objective function in genetic algorithm is shown in figure 16. As can be seen, total travel distance is obtained from the product of importance between each pair letter and distance between them for all keyboard.

```
function z=MyCost(s,model)

    p=s(1:model.n);

    n=model.n;
    w=model.w;
    d=model.d;

    z=0;
    for i=1:n
        for j=1:n
            z=z+w(i,j)*d(p(i),p(j));
        end
    end

end
```

Figure 16: Objective Function Calculation

As it shows in figure 17, 26 keys are on the keyboard, each key assigned to one number, from 1 to 26. The location of each number is constant, but the letter that be assign to each number will be change. The solution of genetic determined each number must be assign to which alphabet, and then automatically each alphabet submit in their places.

Figure 17: Schematic Display of the Keyboard

Chapter 4

RESULTS

Genetic algorithm parameters are tuned by trial-and-error procedure. Table 7 shows the set of values for algorithm parameters on which the trials were performed.

Table 7: Genetic Algorithm Parameters Amount

Symbol	Definition	Amount		
MaxIt	Maximum Number of Iterations	500	1000	1500
nPop	Population Size	1000	3000	5000
pc	Crossover Percentage	2%	4%	6%
pm	Mutation Percentage	6%	7%	8%
beta	Selection Pressure	4	5	6

The best value of each parameters is shown in table 8.

Table 8: Best Value for Parameters

Symbol	Definition	Amount
MaxIt	Maximum Number of Iterations	1000
nPop	Population Size	5000
pc	Crossover Percentage	4%
pm	Mutation Percentage	8%
beta	Selection Pressure	5

Finally, after solving proposed genetic algorithm considering above assumption based on 3000 words extracting from Longman Communication, optimal keyboard layout is designed as figure 18.

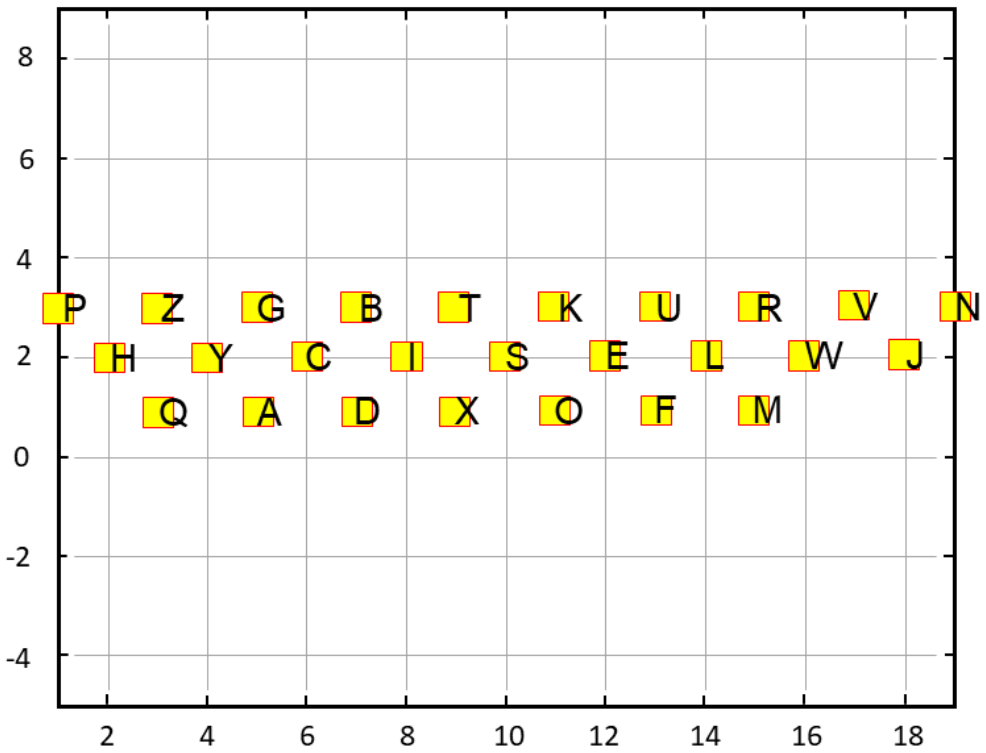

Figure 18: Optimal Keyboard Layout

As shown in figure 18, the new optimal keyboard layout is different from common QWERTY keyboard. Thus, it should be assessed that whether the proposed layout is better than common one or not.

It is necessary to note that the proposed model is implemented in GAMS software, but is not able to solve it optimally due to complexity of the problem. In some case, the model encounter to infeasible solution, otherwise the time out situation is happened.

4.1 Comparison Between QWERTY and Proposed Keyboard Layout

For comparing the QWERTY keyboard and proposed keyboard a Travel distance calculator is created. The software is unique and able to calculate the total travel distance according to different keyboard layout.

The software flowchart is shown in figure 19 and the program code is reported in Appendix D.

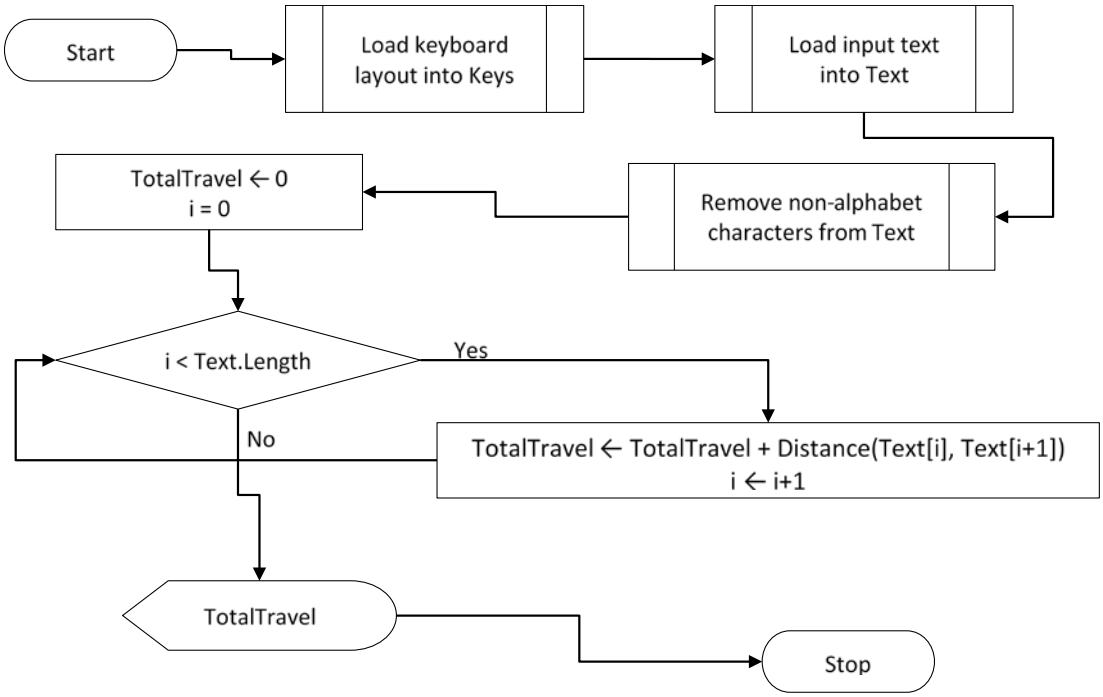

Figure 19: Travel Distance Flowchart

In this section, to validate that the proposed keyboard layout is better than QWERTY ones, 40 various texts including scientific, law, business, historical, lifestyle, study and strategy are selected. All texts are reported in Appendix (B). Therefore, travel distance among letters in each text are firstly calculated for QWERTY keyboard. Then, this process is repeated for proposed keyboard presenting in figure 18. The results are reported in table 9.

Table 9: Travel Distance Calculation for Sample Texts Based on 2 Keyboard Layouts

Type of Text	Title	Travel Distance (cm)		Reduction of Distance (%)
		QWERTY	Proposed	
Scientific	1-Astronomers think they've found a moon the size of Neptune in a distant star system	17,600	16,451	6.53%
	2-There's a zombie attack happening right now. It involves crickets	18,904	16,957	10.30%
	3-The 'all-natural' label on your LaCroix is meaningless, but that doesn't mean it's bad for you	19,719	18,735	4.99%
	4-Megapixels A moth drinks tears from a bird's eye	4,044	4,006	0.94%
	5-MEGAPIXELS For a technicolor nightmare, see this fish in high definition	4,219	3,985	5.55%
Law	6-Property Law – Rights of a Tenant	16,815	16,057	4.51%
	7-Case Analysis Freedom of Speech Law	23,625	22,421	5.10%
	8-Role of Research Design in Socio-Legal Research	19,301	18,097	6.24%
	9-Doctrine of Harmonious Construction	25,977	24,227	6.74%
	10-Contract Law Case Study of Hotel	17,487	16,410	6.16%
Business	11-Critical Discussion of Corporate Social responsibility	37,629	34,307	8.83%
	12-Impacts of Nuclear Energy on Global Business	42,896	40,205	6.27%
	13-STA Travel Business Strategy	10,787	10,268	4.81%
	14-Importance of Strategic Human Resource Management	19,200	18,362	4.36%
	15-Strategic Alliances Reasons and Types	15,529	15,090	2.83%
Historical	16-18th and 21st Amendments	13,552	12,936	4.55%
	17-Missouri Compromise	11,801	11,262	4.57%
	18-Homestead Act	7,549	7,371	2.36%
	19-The Hypocrisy of American Slavery	6,947	6,662	4.10%
	20-Four Freedoms Speech	15,788	15,342	2.82%
Lifestyle	21-Sleep and cognition in children	9,762	9,109	6.69%
	22-Biological clocks and memory	11,576	10,797	6.73%
	23-Eating right for your brain	18,817	17,522	6.88%
	24-Improving attention through nature	20,833	20,088	3.58%
	25-Benefits of herbs & spices for cognition	6,676	6,289	5.80%
	26-Food & Supplements	23,312	21,364	8.36%
	27-Benefits of fruit & vegetables for cognition	6,617	6,313	4.59%
	28-Diabetes - its role in cognitive impairment and dementia	11,241	10,145	9.75%
	29-Tips for better sleep	27,906	25,075	10.14%
	30-The role of sleep in memory	22,769	21,350	6.23%
Study	31-Understanding scientific text	19,720	18,338	7.01%
	32-Reading Scientific Text	24,303	22,790	6.23%
	33-Context & the conditionalization of knowledge	23,697	22,306	5.87%
	34-Retrieval practice & the keyword mnemonic	19,195	18,429	3.99%

	35-Desirable difficulty for effective learning	17,606	16,234	7.79%
Strategy	36-Flashcards	4,716	4,811	-2.01%
	37-Subliminal & sleep learning	18,108	17,291	4.51%
	38-Interested in language	14,144	13,648	3.51%
	39-Improving attention	6,948	6,681	3.84%
	40-Similarity	8,075	7,497	7.16%
Total		665,390	625,228	6.04%

As shown in table 9, distance travelled obtained by proposed keyboard layout are less than QWERTY keyboard in all texts, (except number36) therefore the proposed design can be used for tablet keyboard in reality to reduce time and fatigue. Furthermore, percentage of travel reduction in each text is reported.

Furthermore, according to travel distance other type of classifying is done included under10.000, between 10.000 to 20.000, and more than 20.000 centimeters. Table 10 shows this classification.

Table 10: Travel Distance Reduction Amount for Sample Texts

	Under 10.000	**10.000 to 20.000**	**More than 20.000**	**Total**
Min	-2%	3%	4%	-2%
Max	8%	11%	11%	11.5%
Average	4%	6%	7%	5.9%

As shown in table 10, minimum, maximum, and average amount of reduction in travel distance are reported. As can be seen, this amount for each three measure is growth when travel distance is increased. This trend is obviously depicted in figure 20.

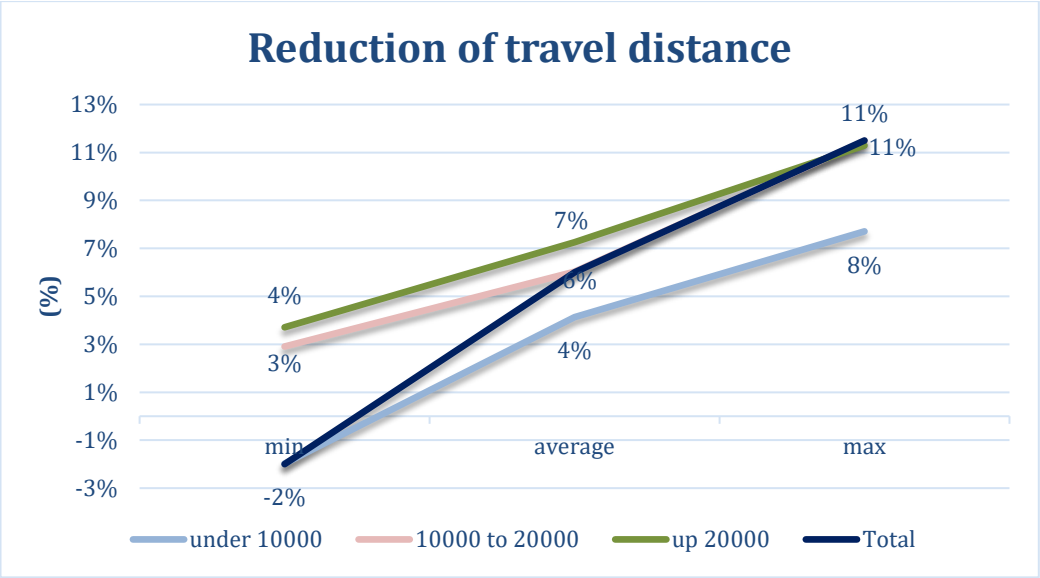

Figure 20: Percent of Reduction for Various Travel Distance

Chapter 5

DISCUSSION

In this section, comparison between QWERTY and new layout of keyboard is done. To do this end, distance between each two letters is calculated for QWERTY keyboard according to the Longman Communication 3000 words described in section 3 and shown in table 6.

Comparison between table 9 and table 5 which is obtained from new layout of tablet keyboard, show that less pressure on hands during typing and it causes less fatigue impose on human when he/she is typing.

Results obtained from table 9 displayed that proposed keyboard layout is improving quality of typing. It means that distance traveled by new layout is less than QWERTY on in most of the time. Therefore, in real world this new layout of keyboard can be used to decrease inconsistencies caused by incorrect typing.

According to table 10, the greater the number of words, the more improvement is achieved. When there are under 10000 travel distance, 4% improvement is obtained while 6% achieved for more than 20000 travel distance. It shows that new keyboard layout can be used for typist which is typed large scale text every day. It helps them to type comfortably rather than old layout.

Figure 16 shows the percent of travel distance reduction in different situation. It shows that a tangible improvement happened when new layout of keyboard is used.

5.1 Comparison

In previous studies most focus was on other elements like doing EMG experiment or speed up typing, in this study the main focus was based on decrease the travel distance between the keys on the keyboard.

Also, distance was measured as unit, not size, it means that the different size of keyboard does not have any affection to the result. The distance between two keys calculated by unit.

For finding a better layout for keyboard, different mathematical model was established with different parameters and different objective function, but in this study a unique mathematical model was described and solved by heuristic method with MATLAB software, the main objective of model was minimizing the total travel distance instead of finding or focusing on other elements and parameters.

Also, two specific software was used for analysis and finding the result, that software specially written for this study and unique. It can be used for other similar study to find out how much each other layout can be improve the total distance.

5.2 Limitation of Study

As mentioned before, a heuristic model was used for solving the mathematical model, as the number of possible solutions is so huge (around 26!) it is not possible to check all of different solution and calculate the objective function for them. In this case a

heuristic method was used. If in the future any new software be able to calculate all of 26! possibility then a new layout with better solution may be will be designed.

Also, in this study assume that user just use one finger during using of keyboard. According to this limitation all of the calculation and model was established.

5.3 Further Study

The result was proved by travel distance calculator's software, but if electromyogram experiment will be done, the result can be verifying also.

As mentioned before all of the software are able to be used with other languages, next study can be focus on other language and design a new keyboard layout for different languages.

According to table 7 and table 8, genetic parameter was selected by try and error. Other parameter can be changing the result (better or worse). Using different method for selecting parameter can be done in the future.

One of the limitations of this study was using only one finger during the type, other method like using two finger or using 10 fingers (both hands and the same time) can be develop for further study.

Chapter 6

CONCLUSIONS

Todays, many people work with electronic device such as mobile or computers. People who work with computers especially typing for long time are faced with ergonomic issues. They should adhere ergonomic rules in order to work comfortably. One of the most important challenges in typing is keyboard layout which is affected on people's fatigue. In this study, a new layout of keyboard is developed to reduce travel distance. In chapter 1, the introduction of keyboard layout is presented. Some explanation about various type of keyboard especially QWERTY is reported in this chapter. A literature review about keyboard layout optimization is presented in chapter 2. Several new researches is reported in this chapter.

Chapter 3 describes the methodology for obtaining new keyboard layout. To do this end, a Text Analyzer software is developed to count the number of letters. Then, the mechanism of word selection is presented. The Longman Communication 3000 words are analyzed with proposed software and consequently, the number of times that each pair of letters were put together is calculated. A mathematical programming is proposed to solve the problem but due to problem complexity, it is not able to solve problem for all English letters. Furthermore, a genetic algorithm is developed to achieve a new keyboard layout with better performance. Proposed meta-heuristic algorithm can design new layout which is different from common QWERTY keyboard.

Comparison between QWERTY and proposed keyboard layout is done in chapter 4. It is shown that new proposed layout improved travel distance rather than old one. As can be seen, in average, about 6 percent improvement have been achieved. Finally, an advantage of new layout is discussed in chapter 5.

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APPENDICES

Appendix A: 3000 Words

Letter	W	Letter	W	Letter	W	Letter	W
abandon	3	desk	2	lock	2	reveal	1
ability	1	desperate	3	long	1	revenue	2
able	1	despite	1	long-term	2	reverse	2
about	1	destroy	2	look	1	review	2
above	1	destruction	3	loose	2	revolution	2
abroad	3	detail	1	lord	2	reward	2
absence	2	detailed	2	lorry	2	rhythm	2
absolute	3	detect	3	lose	1	rice	2
absolutely	3	determination	3	lot	1	rich	2
absorb	3	determine	2	loud	1	rid	2
abuse	3	determined	3	lovely	2	ride	2
academic	2	determiner	1	low	1	ridiculous	2
accept	1	develop	1	lunch	2	right	1
acceptable	3	development	1	machine	1	ring	2
access	1	device	2	machinery	2	rip	2
accident	2	devil	3	magic	2	rise	1
accommodation	2	diagram	3	mail	2	risk	1
accompany	2	diamond	3	main	1	rival	2
according	1	diary	3	mainly	2	river	2
account	1	die	1	maintain	1	road	1
accurate	3	diet	2	maintenance	2	rob	2
accuse	3	differ	3	major	1	rock	2
achieve	1	difference	1	majority	1	role	1
achievement	2	different	1	make	1	roll	2
acid	3	difficult	1	mall	2	roof	2
acknowledge	3	difficulty	1	management	1	room	1
acquire	2	dig	2	manager	1	root	2
across	1	dimension	3	manufacturing	2	rope	2
act	1	dinner	2	many	2	rough	2
action	1	direct	1	map	2	roughly	2
active	2	direction	1	march	2	round	2
activist	3	directly	2	margin	2	route	2
actor	3	director	1	mark	2	routine	2
actual	2	directory	3	market	1	row	2
actually	1	dirt	3	marketing	2	royal	1

ad	3	dirty	3	marriage	2	rub	2
adapt	3	disabled	3	married	2	rubber	2
add	1	disagree	3	marry	2	rubbish	2
addition	1	disappear	2	marvellous	2	rude	2
additional	2	disappoint	3	mass	2	ruin	2
address	2	disappointed	3	massive	2	rule	1
adequate	3	disaster	3	master	2	run	1
adjust	3	disc	3	match	2	rural	2
administration	2	discipline	3	mate	2	rush	2
administrative	3	discount	3	material	1	sack	2
admire	3	disease	1	math	2	sad	2
admission	3	disgusting	2	maths	2	sake	1
admit	1	dish	2	matter	1	same	1
adopt	2	display	2	maximum	2	sample	2
adult	2	dispute	2	may	1	sand	2
advance	2	distance	2	maybe	1	sandwich	2
advanced	3	distant	3	me	1	satellite	2
advantage	1	distinction	3	meal	2	satisfaction	2
advert	3	distinguish	3	mean	1	satisfied	2
advertise	3	divide	3	meaning	1	satisfy	2
advertisement	3	do	1	means	2	sauce	2
advertising	3	document	1	meanwhile	2	sausage	2
advice	2	dollar	2	measure	2	save	1
adviser	3	domestic	2	meet	1	saving	2
affair	1	dominant	3	meeting	2	scared	2
affect	1	dominate	3	member	1	scene	2
afford	3	door	1	membership	2	schedule	2
afraid	2	dot	2	mention	2	scheme	1
after	1	double	2	menu	1	school	1
afternoon	2	down	1	mere	2	science	1
afterwards	3	downstairs	2	merely	3	scientific	2
again	1	downtown	3	mess	2	scientist	2
against	1	dozen	3	message	2	scope	2
age	1	draft	3	messy	2	score	2
aged	3	drag	3	method	2	scratch	2
agency	1	drama	3	metre	2	scream	2
agent	2	dramatic	3	middle	2	screen	2

aggressive	3	draw	1	midnight	2	screw	2
ago	1	drawer	3	might	2	script	2
agree	1	drawing	3	military	2	sea	1
agreement	1	dream	2	millimetre	2	seal	2
agriculture	2	dress	2	mind	1	search	2
ahead	2	drink	2	mine	2	season	1
aid	2	drive	1	mineral	2	seat	1
aim	2	driver	2	minimum	2	second	1
air	1	drop	2	minister	1	secondary	2
aircraft	2	drug	1	ministry	2	secondly	2
airline	3	dude	2	minor	2	secret	2
airport	3	due	1	minority	1	secretary	1
alarm	2	dull	2	miss	2	section	1
album	3	dumb	2	mobile	2	sector	1
alcohol	3	during	1	model	1	secure	1
alive	3	dust	2	month	1	see	1
all	1	duty	1	mood	2	seed	2
allow	1	DVD	2	moon	2	selection	2
allowance	3	each	1	moral	2	sell	1
almost	1	early	1	more	1	sensible	2
alone	1	earn	2	moreover	1	sensitive	2
along	1	earth	2	mostly	2	sentence	2
alongside	3	ease	2	mother	1	separate	2
already	1	easily	1	motion	2	sequence	2
also	1	east	2	motor	2	seriously	1
alter	3	eastern	2	motorway	2	servant	2
alternative	2	easy	1	mountain	2	serve	1
although	1	eat	1	mouse	2	service	1
altogether	3	economic	1	mouth	1	session	2
always	1	economics	2	move	1	set	1
amazing	2	economy	1	movement	1	settle	2
ambition	3	edge	2	movie	2	settlement	2
ambulance	3	edition	2	much	1	several	2
among	1	editor	2	mud	2	severe	2
amount	1	education	1	murder	2	sew	2
an	1	educational	2	museum	2	sex	2
analyse	3	effect	1	mushroom	2	sexual	2

analysis	1	effective	1	music	1	shadow	2
analyst	2	effectively	2	musical	2	shake	2
ancient	2	efficiency	2	must	1	shall	1
and	1	efficient	2	my	1	shame	2
anger	3	effort	1	myself	1	shape	2
angle	3	egg	1	mystery	2	share	1
angry	3	either	2	nail	2	sharp	2
animal	1	elderly	2	naked	2	sharply	2
announce	1	elect	2	name	1	shave	2
announcement	3	election	1	narrow	2	she	1
annoy	3	electric	2	nasty	2	shed	2
annual	2	electrical	2	nation	2	sheep	2
another	2	electricity	2	national	1	sheet	2
answer	1	electronic	2	native	2	shelf	2
anticipate	3	element	1	natural	1	shell	2
anxiety	3	elevator	2	naturally	2	shelter	2
anxious	3	else	1	nature	1	shift	2
any	1	elsewhere	2	naughty	2	shine	2
anybody	3	email	2	near	1	ship	2
anyhow	3	embarrassed	2	nearby	2	shirt	2
anyone	1	emerge	2	nearly	1	shock	2
anything	1	emergency	2	neat	2	shocked	2
anyway	2	emotion	2	necessarily	2	shocking	2
anywhere	3	emotional	2	necessary	1	shoe	2
apart	1	emphasis	2	neck	2	shoot	2
apartment	3	emphasize	2	need	1	shop	1
apologize	2	empire	2	neighbourhood	2	shopping	2
apology	3	employ	2	nerve	2	short	1
apparent	2	employee	2	net	1	shortly	2
apparently	2	employer	2	nevertheless	1	should	2
appeal	1	employment	1	newly	1	shoulder	2
appear	1	empty	2	newspaper	2	shove	2
appearance	2	enable	1	next	1	show	2
apple	3	encounter	2	nice	2	shrug	2
application	1	encourage	1	nicely	2	shut	3
apply	1	encouraging	2	night	1	sick	2
appoint	2	end	1	nil	2	side	2

appointment	2	enemy	2	no	1	sight	2
appreciate	3	energy	2	noise	2	sign	2
approach	1	engage	1	noisy	2	signal	2
appropriate	1	engine	3	none	2	significance	2
approval	3	engineer	2	nonsense	2	significant	2
approve	2	engineering	2	nope	2	significantly	2
approximate	3	enhance	3	nor	1	silver	2
architect	3	enjoy	1	normal	1	similar	1
architecture	3	enjoyable	2	normally	2	similarly	2
area	1	enormous	2	north	2	simple	1
argue	1	enough	1	northern	2	simply	1
argument	1	enquiry	2	nose	2	sin	2
arise	2	ensure	2	not	1	since	2
arm	1	enter	1	notably	2	sing	2
armed	3	enterprise	1	note	1	singer	2
army	1	entertainment	2	nothing	1	single	1
around	1	enthusiasm	3	notice	2	sink	2
arrange	2	enthusiastic	2	notion	2	sir	2
arrangement	2	entire	2	novel	2	sister	1
arrest	3	entirely	2	now	1	sit	1
arrival	3	entitle	2	nowadays	2	site	2
arrive	1	entrance	2	nowhere	2	situation	1
art	1	entry	2	nuclear	2	size	1
article	1	envelope	2	nuisance	2	skill	1
artificial	3	environment	1	number	1	skin	2
artist	2	environmental	2	numerous	2	skirt	2
as	1	equal	2	nurse	2	sky	2
ashamed	3	equally	2	nut	2	sleep	2
aside	3	equipment	2	o'clock	2	slice	2
ask	1	equivalent	2	object	2	slide	2
asleep	2	er	2	objection	2	slight	2
aspect	1	era	3	objective	2	slip	2
assess	2	error	2	obligation	3	slow	2
assessment	2	escape	2	observation	3	slowly	2
assignment	2	especially	1	obtain	2	small	1
assist	3	essay	2	obvious	2	smart	2
assistance	2	essential	2	obviously	2	smell	2

assistant	3	essentially	2	occasion	2	smile	2
associate	2	establish	3	occasional	2	smoke	2
association	1	establishment	1	occupation	2	snap	2
assume	1	estate	2	occupy	2	snow	3
assumption	2	estimate	2	occur	1	so	2
assure	3	even	1	ocean	2	so-called	2
at	1	evening	1	odd	3	soap	2
atmosphere	2	ever	1	odds	3	social	2
attach	2	every	1	of	1	society	2
attack	2	everybody	2	off	1	sock	2
attempt	1	everyone	1	offer	1	soft	2
attend	2	everything	1	office	1	software	2
attention	1	everywhere	2	officer	2	soldier	2
attitude	1	evidence	1	official	1	sole	2
attorney	3	evil	2	often	2	solicitor	3
attract	2	exact	2	oil	1	solid	2
attraction	3	exactly	2	OK	2	solution	3
attractive	2	exam	2	old	1	solve	2
audience	2	examination	2	on	1	some	1
aunt	3	examine	2	once	1	somebody	2
author	2	excellent	2	one	1	somehow	2
authority	1	except	2	onion	2	someone	1
automatic	3	exception	2	only	1	something	1
automatically	3	exchange	1	onto	2	sometimes	1
autumn	3	excitement	2	open	1	somewhat	2
available	1	exciting	2	opening	2	somewhere	2
average	2	exclude	2	operate	2	son	1
avoid	1	excuse	2	operation	1	song	2
awake	3	executive	3	operator	2	soon	1
award	2	exercise	2	opinion	2	sore	2
aware	1	exhibition	2	opponent	2	sorry	2
awareness	3	exist	2	opportunity	1	sort	1
away	1	existence	2	oppose	2	soul	2
awful	1	existing	2	opposite	2	sound	1
awkward	3	exit	2	opposition	2	soup	2
baby	1	expand	2	option	2	source	1
back	1	expansion	2	or	1	south	2

background	2	expect	1	orange	2	southern	1
backwards	3	expectation	2	order	1	spare	1
bacon	3	expenditure	2	ordinary	2	speaker	2
bad	1	expense	2	organ	2	special	1
badly	3	expensive	2	organic	2	specialist	2
bag	2	experience	1	organization	2	species	2
bake	3	experienced	2	organize	1	specific	1
balance	2	experiment	2	organized	2	specifically	2
ball	2	experimental	2	original	1	specify	2
ban	3	expert	2	originally	2	speech	2
band	2	explain	1	other	2	speed	1
bang	3	explanation	2	otherwise	2	spell	2
bank	1	explore	2	ought	2	spelling	2
bar	1	explosion	2	our	2	spend	1
barrier	3	export	2	ours	1	spill	2
base	1	expose	2	ourselves	2	spin	2
baseball	2	express	1	out	2	spirit	2
basic	1	expression	2	outcome	1	spiritual	2
basically	1	extend	2	outside	1	spite	2
basis	1	extension	2	outstanding	2	split	2
basket	3	extensive	2	oven	2	spoil	2
bat	3	extent	1	over	1	spokesman	2
bath	2	external	2	overall	1	spoon	2
battle	2	extra	2	overcome	2	sport	2
be	1	extraordinary	2	overseas	3	spot	2
beat	3	extreme	2	overtime	2	spray	2
beautiful	3	extremely	2	owe	2	spread	2
beer	1	eye	1	own	1	spring	2
behind	3	face	1	owner	2	squad	2
belief	2	facility	1	ownership	2	square	2
believe	1	fact	1	pace	2	squeeze	2
bell	1	factor	1	pack	2	stable	2
belong	3	factory	2	package	2	staff	2
below	2	fail	1	packet	2	stage	1
bench	2	failure	2	pad	2	stair	2
bend	3	fair	1	page	1	stake	2
beneath	2	fall	2	pain	2	stall	2

benefit	2	false	1	paint	2	stamp	1
beside	3	familiar	2	painting	2	stand	1
best	1	family	2	pair	2	standard	2
bet	3	famous	1	palace	2	star	2
better	1	fancy	2	pale	2	stare	2
between	2	fantastic	2	pan	2	start	2
beyond	1	far	1	panel	2	starve	2
bid	3	farmer	2	panic	2	state	2
big	2	fascinating	2	pants	2	statement	1
bike	1	father	2	paper	1	station	1
bill	2	fault	1	parcel	2	statistic	2
bin	1	favour	3	pardon	2	status	2
bird	2	favourite	2	parent	1	stay	1
birth	2	fear	2	park	2	steady	2
bit	1	feature	1	parking	2	steak	2
bite	3	federal	3	parliament	2	steal	2
bitter	3	feedback	2	part	1	steam	2
blind	2	feel	1	participate	2	steel	2
block	3	feeling	2	particular	1	steep	2
boiler	3	fellow	1	particularly	1	step	1
border	2	female	2	partly	2	stick	2
bored	3	fence	3	partner	2	stiff	2
boring	2	festival	2	partnership	2	still	1
born	2	fetch	3	party	1	stir	2
borrow	3	few	2	pass	1	stock	2
boss	3	field	2	passage	2	stomach	2
both	2	fight	1	passenger	2	stone	1
bother	3	figure	2	passion	2	stop	1
bottle	2	fill	1	past	1	storage	2
bottom	3	finally	1	path	2	store	1
bounce	3	fine	1	patience	2	storm	2
bound	3	fishing	2	patient	1	story	1
bowl	2	fixed	2	pattern	1	straight	2
boy	1	flat	1	pause	2	straightforward	2
boyfriend	3	folk	1	pay	1	strain	2
brain	2	following	1	payment	1	strange	2
branch	2	foot	1	peace	2	stranger	2

brave	3	football	2	peaceful	2	strategic	2
bread	3	for	1	peak	2	strategy	2
break	1	force	1	pen	2	straw	2
breakfast	2	foreign	1	penalty	2	strawberry	2
breast	3	forest	2	pencil	2	stream	2
breath	2	forever	2	penny	2	street	1
breathe	3	forget	1	pension	2	strength	2
brick	3	forgive	2	people	1	strengthen	2
bridge	2	fork	1	pepper	2	stress	2
brief	2	formal	2	per	1	stretch	2
briefly	3	formally	2	perceive	2	strike	2
bright	2	formation	2	percent	2	string	2
brilliant	3	former	1	percentage	2	strip	2
bring	1	formula	2	perception	2	strongly	1
broad	2	forth	2	performance	1	structure	2
brother	1	fortnight	2	perhaps	1	struggle	2
brown	2	fortunate	2	period	1	student	1
brush	3	fortune	2	permanent	2	studio	2
buck	1	forward	1	permission	2	study	2
bucket	2	foundation	2	permit	2	subject	1
buddy	3	frame	2	person	1	submit	1
budget	2	frankly	2	personal	1	subsequent	2
bug	3	free	1	personality	2	subsequently	2
build	1	freedom	2	personally	2	substance	2
builder	3	freeway	2	personnel	2	substantial	2
building	1	freeze	2	perspective	2	succeed	2
bump	3	freezer	2	persuade	2	success	1
bunch	2	frequent	2	petrol	2	successful	1
burn	3	frequently	2	phase	2	successfully	2
burst	3	fresh	2	philosophy	2	such	2
bury	3	fridge	2	phone	2	suck	2
bus	2	friend	1	photo	2	sudden	2
business	1	friendly	2	photocopy	2	suddenly	1
busy	2	friendship	2	photograph	2	suffer	1
but	1	frightened	2	phrase	2	sufficient	2
butcher	3	from	1	physical	1	sugar	2
butter	2	front	2	physically	2	suggest	1

button	2	fruit	2	physics	2	suggestion	2
buy	1	fry	2	piano	2	suit	2
buyer	2	fuel	2	picture	1	suitable	2
by	3	fulfil	2	pie	2	sum	2
bye	1	full	1	piece	1	summer	1
cabinet	2	fully	2	pile	2	sun	1
cake	3	fun	2	pin	3	super	2
calculate	2	function	1	pink	2	supermarket	2
calculation	3	fund	1	pint	2	supper	2
call	1	fundamental	2	pipe	2	supporter	2
calm	3	funeral	2	pitch	2	suppose	1
camera	3	funny	2	pity	2	sure	1
camp	3	furniture	2	pizza	2	surely	2
campaign	2	further	1	plain	2	surface	1
can	1	fuss	2	plan	1	surgery	2
cancel	2	future	1	plant	1	surprise	2
cancer	2	gain	2	plastic	2	surprised	2
candidate	2	gallery	2	plate	2	surprising	2
cap	3	game	1	platform	2	surprisingly	2
capable	2	gap	2	play	1	surround	2
capacity	2	garage	2	player	1	survey	2
captain	3	garbage	2	pleasant	2	survival	2
capture	3	garden	1	please	2	survive	3
car	1	gas	2	pleased	2	suspect	2
card	2	gate	3	pleasure	3	suspicion	2
care	2	gather	2	plug	2	sustain	2
career	2	gene	1	plus	2	swap	3
careful	2	giant	2	pocket	2	swear	2
carefully	2	gift	1	poet	2	sweep	2
carrot	3	go	1	poetry	2	sweet	2
cast	3	good	2	point	1	swim	2
catalogue	3	goods	2	policeman	2	switch	2
cease	3	government	1	policy	3	system	2
ceiling	3	grab	2	polite	1	table	2
celebrate	3	gradually	2	political	2	tablet	2
celebration	3	grammar	2	politician	1	tail	2
cell	2	grand	2	politics	2	take	3

cellphone	3	grandad	2	poll	2	tale	2
cent	1	grandfather	2	pollution	2	talent	2
centimetre	3	grandma	2	pond	2	talk	2
central	1	grandmother	2	pool	2	tall	1
centre	1	grandpa	2	poor	2	tank	2
century	1	granny	2	popular	2	tap	2
cereal	3	grant	2	population	1	tape	2
certain	1	graph	2	pose	2	target	2
certainly	1	grass	2	position	2	task	2
certificate	3	grateful	2	positive	1	taste	1
chain	2	great	1	possession	2	tax	2
chair	2	greatly	2	possibility	2	taxi	1
chairman	1	green	2	possible	2	tea	2
challenge	2	grey	2	post	2	teach	2
champion	3	grocery	2	poster	2	teacher	1
championship	3	gross	2	pot	2	teaching	2
chance	1	ground	1	potato	2	team	1
channel	2	group	1	potential	2	tear	2
chap	2	grow	1	pound	3	technical	2
chapter	1	growth	1	pour	2	technique	1
character	1	guarantee	2	poverty	3	technology	1
characteristic	2	guard	2	power	3	telephone	2
characterize	3	guess	2	powerful	1	television	1
charge	1	guest	2	practically	2	tell	1
charity	3	guidance	2	practice	1	telly	2
chart	3	guide	2	praise	2	temperature	1
chase	3	guilty	2	pray	2	tent	1
chat	2	guitar	2	prayer	2	terrible	2
cheap	2	gun	2	precise	2	terribly	2
cheat	3	halfway	2	precisely	2	territory	2
check	2	hall	2	predict	2	terror	2
cheek	3	hand	1	prefer	2	terrorist	2
cheese	3	handbag	2	preference	2	ters	2
chemical	3	handle	2	pregnant	2	test	1
chemist	3	handy	2	premise	2	text	1
chemistry	2	hang	2	prep	1	than	1
cheque	2	happen	1	preparation	2	thank	2

cherry	2	happy	1	prepare	3	thanks	2
chief	2	hard	1	prepared	1	that	1
child	1	hardly	2	presence	2	the	2
childhood	3	harm	2	present	1	theatre	2
chip	3	hat	2	presentation	2	their	1
chocolate	2	hate	2	preserve	3	theirs	2
choice	1	have	1	president	2	them	1
choose	1	he	1	press	2	theme	2
chop	3	health	2	pressure	1	themselves	1
chuck	3	hear	3	presumably	2	then	1
cigarette	3	hearing	2	presume	3	theoretical	2
cinema	3	heart	2	pretend	2	theory	1
circle	2	heaven	2	pretty	2	there	1
circuit	3	heavily	2	prevent	1	therefore	1
circumstance	1	heavy	1	previous	1	they	1
citizen	2	height	2	previously	2	thick	2
city	2	hell	2	price	2	thin	2
classic	3	hello	2	pride	2	thing	1
classical	3	help	1	priest	2	think	1
classroom	3	helpful	2	primarily	2	this	2
clean	2	hence	2	primary	3	though	1
clear	1	her	1	princess	3	thought	1
clearly	1	here	1	principal	3	threat	2
clerk	3	hero	2	principle	2	threaten	2
clever	2	hers	2	printer	2	three	2
click	2	herself	1	prior	2	throat	2
climate	1	hesitate	2	priority	2	through	1
clock	2	hi	2	prison	2	throughout	2
close	1	hide	2	prisoner	2	throw	1
closed	2	high	1	private	2	thus	1
cloth	2	highlight	2	probably	2	ticket	2
coach	2	highly	2	proceeding	2	tidy	2
coal	2	highway	2	process	1	tie	2
coast	2	hill	2	produce	1	tight	2
coat	3	him	1	producer	2	tile	2
code	2	himself	1	product	1	till	2
coffee	2	hire	2	production	2	time	1

coin	3	his	1	profession	1	tiny	2
cold	1	historian	2	professional	1	tired	1
collapse	3	historical	2	professor	2	to	1
collar	3	history	1	profile	2	today	1
colleague	2	hit	2	profit	1	together	1
collect	2	hold	1	program	1	tomato	2
collection	1	holder	2	programme	1	tone	1
college	2	holding	2	progress	2	top	1
combination	2	hole	2	project	1	tourist	2
combine	2	holiday	2	promise	2	towards	1
comfortable	3	holy	2	promote	2	tower	1
command	2	home	1	promotion	2	track	1
commercial	2	homework	2	prompt	2	traditional	1
commission	2	honest	2	pron	1	train	1
commit	2	honestly	2	proof	2	transaction	2
commitment	2	honey	2	proper	2	transfer	2
committee	1	honour	2	properly	2	translate	2
common	1	hook	2	proportion	2	travel	2
communicate	3	hope	1	proposal	1	treat	2
communication	1	hopefully	2	propose	2	treatment	1
community	1	hopeless	2	proposed	2	treaty	2
company	1	horrible	2	prosecution	2	tree	1
comparison	2	horror	2	prospect	2	tremendous	2
competition	1	horse	1	protect	2	trend	2
competitive	3	hospital	1	protection	2	trick	2
complain	3	host	2	protest	2	tricky	2
complaint	3	hot	1	proud	2	trip	2
complete	1	household	2	prove	1	troop	2
completely	2	housing	2	provide	1	trouble	2
complex	2	how	1	provided	2	trousers	2
complicated	2	however	1	providing	2	truck	2
component	2	huge	2	provision	1	true	1
comprehensive	3	human	1	psychological	2	truly	2
comprise	2	hungry	2	psychology	2	trust	2
concentrate	1	hunt	2	pub	2	truth	2
concept	2	hurry	2	public	1	try	1
concerned	1	hurt	2	publication	2	tube	2

concerning	3	husband	1	publicity	2	tune	2
concert	3	ice	2	publish	1	tunnel	2
conclusion	2	idea	1	publisher	2	turn	1
conduct	2	ideal	2	pudding	2	TV	2
conference	1	ideally	2	pull	1	twice	2
confident	3	identify	1	punch	2	twist	2
confine	2	identity	2	punishment	2	type	1
confusing	3	idiot	2	pupil	1	typical	2
confusion	3	if	1	purchase	2	tyre	2
congratulation	3	ignore	2	pure	2	ugly	2
connect	2	ill	2	purely	2	ultimate	2
connection	2	illegal	2	purple	2	ultimately	2
conscious	2	illness	2	purpose	2	unable	3
consciousness	2	illustrate	2	purse	2	unbelievable	2
consequence	2	image	1	pursue	2	under	1
considerable	2	imagination	2	push	2	underneath	2
considerably	2	imagine	2	put	1	understanding	2
consistent	3	immediate	2	qualification	2	undertake	2
constantly	2	immediately	1	qualify	2	unemployed	2
constitute	3	impact	2	quality	1	unemployment	2
construct	3	implement	2	quantity	2	unfair	2
construction	3	implication	2	quarter	2	unfortunate	2
consumer	2	imply	2	queen	2	unfortunately	2
consumption	2	import	2	question	1	unhappy	3
contemporary	2	importance	1	queue	2	uniform	2
content	2	important	1	quick	2	union	1
continue	2	impose	2	quickly	1	unique	2
continuous	1	impossible	2	quid	2	unit	2
contract	1	impress	2	quiet	2	united	2
contrast	2	impression	2	quietly	2	unity	3
contribute	2	impressive	2	quit	2	universal	2
contribution	2	improve	1	quite	2	universe	2
convenient	3	improvement	2	quote	2	university	1
convention	2	in	1	race	2	unknown	2
conventional	2	inch	2	racing	2	unless	2
conversation	3	incident	2	radical	2	unlike	1
conviction	3	include	1	radio	2	unlikely	2

cooker	2	including	1	rail	2	until	2
cookie	3	income	1	railway	2	unusual	1
cool	2	incorporate	2	rain	2	up	1
cooperation	2	increase	1	raise	1	upset	2
copy	2	increasingly	2	range	1	upstairs	2
corn	3	incredible	2	rank	2	urban	2
corner	2	independence	2	rapid	2	urge	2
correct	2	independent	2	rapidly	2	urgent	2
corridor	2	index	2	rare	2	used	2
cost	2	indicate	1	rarely	2	useful	1
cottage	2	indication	2	rate	1	user	1
cotton	2	individual	1	rather	2	usual	2
could	2	industrial	1	ratio	2	usually	1
council	2	industry	1	raw	2	vacation	2
count	2	inevitable	2	reach	1	vague	2
counter	3	inevitably	2	react	2	van	1
country	1	infant	2	reaction	2	variation	2
countryside	3	infection	2	read	1	variety	1
county	2	inflation	2	reader	2	various	1
couple	1	influence	1	readily	2	vary	2
courage	3	inform	2	reading	2	vast	2
course	1	informal	2	ready	2	vehicle	2
court	1	information	1	real	1	version	2
cousin	2	ing	2	realistic	2	very	2
cover	1	initial	2	reality	2	via	1
cow	2	initially	2	realize	1	virtually	2
crack	3	initiative	2	really	1	virus	2
craft	3	injure	2	reason	1	visible	2
crash	3	injury	2	reasonable	2	vision	3
crazy	2	inner	2	reasonably	2	visit	1
create	1	innocent	2	recall	2	visitor	2
creation	2	innovation	2	receipt	2	visual	2
creative	3	input	2	receive	1	vital	3
creature	3	inside	2	recent	1	voice	2
credit	2	insist	2	recently	1	volume	2
crew	3	inspection	2	reception	2	vote	2
crime	2	inspector	2	recipe	2	vulnerable	2

criminal	2	install	2	reckon	2	wage	2
crisis	2	instead	1	recognition	2	wait	2
criterion	2	institute	2	recognize	1	wake	2
critic	3	institution	1	recommend	2	walk	2
critical	2	instrument	2	recommendation	2	wall	2
criticism	2	insurance	2	record	1	wander	2
criticize	3	intellectual	2	recording	2	want	1
crop	3	intelligence	2	recover	2	war	1
cross	2	intelligent	2	recovery	2	ward	2
crowd	2	intention	2	red	1	wardrobe	2
crown	3	interaction	2	reduce	1	warm	2
crucial	2	interest	1	reduction	2	warning	2
cruel	3	interested	2	refer	1	wash	2
cry	2	interesting	2	reference	1	washing	2
cultural	2	interjection	2	reflect	1	waste	2
culture	1	internal	2	reflection	2	watch	1
cup	1	international	1	reform	2	water	1
cupboard	2	internet	2	refrigerator	2	wave	2
curious	3	interpret	2	refuse	1	way	1
currency	2	interpretation	2	regard	1	we	1
current	2	interval	2	regime	2	weak	2
currently	2	interview	2	region	1	weakness	2
curtain	3	into	1	regional	2	wealth	2
curve	3	introduce	1	register	2	weapon	2
cushion	3	introduction	2	registration	2	wear	1
custom	3	invest	2	regret	2	weather	2
customer	1	investigate	2	regular	2	web	2
cut	1	investigation	2	regularly	2	website	2
cute	2	investment	1	regulation	2	wedding	2
cycle	3	invite	2	reinforce	2	week	1
dad	1	involve	1	reject	2	weekend	2
daddy	2	involved	2	relate	1	weekly	2
daft	2	involvement	2	related	2	weigh	2
daily	2	iron	2	relation	1	weight	2
damage	2	island	2	relationship	1	weird	2
dance	3	issue	1	relative	2	welcome	2
danger	2	kilometre	2	relatively	2	welfare	2

dangerous	2	kind	3	relax	2	well	1
dare	3	king	2	release	2	west	2
dark	1	kiss	1	relevant	2	what	1
darkness	3	kit	2	relief	2	whatever	2
darling	2	kitchen	2	relieve	2	whatsoever	2
data	1	knee	2	religion	2	when	2
database	3	knock	2	religious	2	whenever	2
date	1	know	1	rely	2	where	2
daughter	1	knowledge	1	remain	1	whereas	2
day	1	known	2	remaining	2	wherever	2
dead	1	lab	2	remains	2	whether	1
deaf	3	label	2	remark	2	which	2
deal	1	laboratory	2	remarkable	2	while	1
dealer	3	labour	1	remember	1	whisky	1
dear	1	lack	2	remind	2	who	2
death	1	lad	2	remote	2	whole	1
debate	2	ladder	2	remove	1	wide	1
debt	2	lady	2	rent	2	widely	3
decade	2	lake	2	repair	2	widespread	2
decent	3	lamb	2	repeat	2	wild	1
decide	1	land	1	replace	1	win	2
decision	1	landlord	2	replacement	2	window	1
declare	2	landscape	2	reply	2	wine	2
decline	2	lane	2	report	1	wire	1
deep	1	language	1	reporter	2	with	1
deeply	3	large	1	represent	1	without	1
defeat	3	largely	2	representation	2	witness	2
defence	1	last	1	representative	2	wonder	1
defend	3	late	1	republic	2	wooden	2
define	2	later	1	reputation	2	word	1
definite	3	lead	1	requirement	1	working	2
definitely	1	leadership	2	rescue	2	worried	2
definition	2	leaf	1	research	1	worrying	2
degree	1	least	2	reserve	2	worth	2
delay	3	leather	1	resident	2	yesterday	1
deliberately	3	left	2	residential	2	yet	1
deliver	2	leg	1	resign	2	you	1

delivery	3	legal	1	resignation	2	young	1
demand	1	legislation	2	resist	2	youngster	2
democracy	2	leisure	2	resistance	2	your	1
democratic	2	lend	3	resolution	2	yours	2
demonstrate	2	length	1	resolve	2	yourself	2
demonstration	3	less	2	resort	2	youth	2
dentist	3	lesson	1	resource	1		
deny	2	lid	2	respect	1		
department	1	lie	1	respectively	2		
departure	2	life	1	respond	2		
depend	2	like	1	response	1		
dependent	3	likely	1	responsibility	1		
deposit	3	limit	2	responsible	2		
depression	3	limited	3	rest	1		
depth	3	line	1	restaurant	2		
derive	3	lip	2	restore	2		
describe	1	list	1	restrict	2		
description	2	literally	1	restriction	2		
desert	3	literary	2	result	1		
deserve	3	literature	2	retain	2		
design	1	little	2	retire	2		
designer	3	live	1	retirement	2		
desire	2	local	1	return	1		

Appendix B: Text for Travel Distance

1-Astronomers think they’ve found a moon the size of Neptune in a distant star system Nearly eight thousand light-years away from Earth, there’s a star about the same size as our sun. Like our own solar system, that distant star is orbited by a planet about the same size as Jupiter. But that’s where the similarities end. Around that planet circles a Neptune-sized gas giant, which may be the first moon discovered outside the solar system, and the largest moon ever observed.

Over the past 20 or so years, scientists have confirmed the existence of nearly 3,800 exoplanets, or planets around other stars. However, although nearly 200 moons are known to orbit planets in our solar system—Jupiter alone has at least 79—up to now researchers had not yet detected any moons around exoplanets. Their discovery was published today in Science Advances.

To look for such "exomoons," astronomers from Columbia University examined data from NASA's Kepler space telescope on 284 transiting planets—worlds that passed between their stars and the observatory, resulting in a brief dimming of the light of those stars. They focused on worlds that took more than 30 days to complete orbits around their stars—prior work suggested that worlds that orbited in less time were likely too close to their stars for any moons to survive.

The scientists detected anomalies hinting at a moon around the exoplanet Kepler-1625b. This gas giant is about the same diameter as Jupiter, and orbits the solar-mass star Kepler-1625 about 7,825 light-years from Earth in the constellation Cygnus the swan.

The researchers then requested and received about 40 hours of time on NASA's Hubble Space Telescope to analyze Kepler-1625b during its 19-hour-long transit across the face of its star. Using Hubble, which is about four times more precise than Kepler, they detected two sets of telltale signs that suggested the presence of an exomoon. "We indeed conclude that a moon is an excellent explanation for the data in hand," said study senior author David Kipping, an astrophysicist at Columbia University.

First, after the exoplanet passed in front of its star, the researchers detected a second and much smaller decrease in the star's brightness 3.5 hours later. This supports a scenario where a moon trailed the planet like a dog following its owner.

Second, the astronomers found the planet began its transit nearly 80 minutes earlier than predicted. This is consistent with a picture where a moon's gravitational tug would cause its planet to wobble from its predicted location. Although the gravitational pull of another planet could in principle also cause this anomaly, Kepler found no evidence for additional planets around this star during its four-year mission.

"It sounds like they struck gold," said astrophysicist Sean Raymond at the University of Bordeaux in France, who did not take part in this work. "Moons are out there and findable. It's an exciting next step in exoplanet exploration."

The researchers estimated the exomoon, dubbed Kepler-1625b-i, is only 1.5 percent the mass of its companion planet, a ratio nearly that of Earth and its moon. However, that still means the exomoon may be gargantuan—Kepler-1625b is likely several times Jupiter's mass, so its moon is likely about the mass and diameter of Neptune.

The size of the moon is surprising—"all the large moons in the solar system are at most about 1/10,000th as massive as their host planets," Raymond said. The pair are so large that it "could also be regarded as a binary planet system," said Avi Loeb, chair of Harvard University's astronomy department, who did not participate in this study.

"The biggest things will be the easiest to find," Kipping said. "This may not represent a particularly common type of moon system—it's just it's for the easiest for us to find."

The researchers estimated the exomoon orbits about 33 million kilometers from its world. This means it may lie close enough for its planet's gravitational pull to rip it apart. But there’s nothing like this in our solar system for the researchers to observe directly. To study the dynamics of the planet-moon pair, the researchers created computer models to see how the two might interact. "In about three-quarters of the simulations that we did, we find the moon is perfectly stable," Kipping said. "We don't have any reason to believe that orbit is unstable."

Kepler-1625b orbits its star about the same distance that Earth does the sun. That puts the exoplanet and its moon within their star's habitable zone—the area around the star warm enough for standing bodies of liquid water to survive. There is life virtually wherever there is water on Earth, so the hunt for alien life often focuses on habitable zones.

Both Kepler-1625b and its potential newfound moon are gas giants, and so cannot support the bodies of water needed for life as we know it to survive. However, "if there are additional rocky moons orbiting the large planet, they might be habitable," Loeb said. "This is the most exciting prospect for future follow-ups on this discovery."

The size of this potential exomoon raises questions about how it formed. Some moons, like Earth's, are thought to have coalesced from the debris of a giant impact against their companion planet. Others, like Neptune's moon Triton, likely started off as independent bodies only to later get ensnared by their planet's gravitational pull. However, neither of these scenarios seems to fit this exomoon, said study lead author Alex Teachey, an astrophysicist at Columbia University—it is difficult to see how an impact against a gas giant would split off a moon, or how a moon of such size could get captured.

Another possibility is that this exomoon may have formed from the same material as its parent planet, as is suspected with Jupiter and its moons. New models of moon formation have suggested "a small fraction of moons can end up being as massive as about 1 percent of their host planet mass, which is about the case for Kepler-1625b," Raymond said.

In the future, hunts for exomoons will likely look at exoplanets farther away from their stars than Earth is from the sun, Kipping said. These searches with Hubble or NASA's upcoming James Webb Space Telescope may even turn up exomoons smaller than Jupiter's largest ones, he added.

The scientists noted they are still urging caution about their find. "The first exomoon is obviously an extraordinary claim, and it requires extraordinary evidence," Teachey said. "Furthermore, the size we've calculated for this moon, about the size of Neptune, has hardly been anticipated, and so that too is reason to be careful here."

The researchers hope to use Hubble again to monitor Kepler-1625b and confirm the exomoon's existence.

2-There's a zombie attack happening right now. It involves crickets

In a muggy room at the University of New Mexico, packed with racks of plastic tanks, themselves packed with snails, biologist Ben Hanelt and undergrad Rachel Swanteson-Franz cultivate nematomorph zombie worms. On account of some of the snails having tropical tendencies, the temperature is set to precisely 82 degrees Fahrenheit (according to a comically large Flavor Flav-style thermometer hung from one of the racks). It smells like you’d expect over 100 tanks of snails to smell at precisely 82 degrees.

Swanteson-Franz fills a Pyrex bowl with a finger or two of water, pulls a cricket from a bin, and drops it in. As soon as its host hits the water, the nematomorph makes its move, squirming sinuously out of a hole it’s drilled in the cricket’s belly. This appears

to be not such a big deal for the cricket. The worm wriggles back and forth, growing longer and longer, but only once in the 50 seconds it takes the worm to emerge does the insect so much as twitch its legs. The rest of the ordeal it just floats there, as if a worm seven times its length isn't spilling out of its belly and swimming free. Even when the worm is at last liberated, the cricket simply floats—even as the whips of the nematomorph's long, thin body occasionally smack it around the bowl.

Swanteson-Franz isn't done. She drops another cricket in another Pyrex of water and sets the bowl next to the first. This cricket has more moxie. It struggles to swim away from the alien emerging from its gut, bouncing off the wall. But before the second subject even finishes with its ordeal, Swanteson-Franz adds another Pyrex-cum-cricket to the mix.

This new subject, too, tries to flee the parasite it now finds itself birthing, as its compatriot in the bowl next door continues its own quest for relief. At last the second cricket's worm frees itself, followed not long after by the third. Everyone now rests. And while the crickets will never know it, in this lab they got off easy, for in nature their ordeal is far more precarious.

It was no accident Hanelt and I found so many nematomorphs in a cattle trough earlier that day. (Nematomorphs are also known as horsehair worms, because ranchers will discover them wriggling in their waters.) Find a puddle or stream or even an abandoned cup in the hills of New Mexico and you're almost sure to find the worms. And indeed, across the United States and all around the planet—over 300 nematomorph species tallied so far—people find them in dog bowls and, more troublingly, toilets. They'll stomp on a cricket, pick it up with a tissue, toss it in the commode, and flush. Sometime later the worm will make its way back up the pipes and the poor homeowner will email Hanelt in a panic, thinking a human in the family is producing these things, when in fact that's impossible—unless you're a family of crickets. "I could have become a rich man by selling some sort of sugar pill," Hanelt giggles. "Here, that's a really bad parasite, take this. It'll cost ya 400 bucks. It'll cure you right away!"

What's really happening is a zombie attack of global proportions. When a nematomorph gets into a cricket, the insect doesn't act at all differently, even as the parasite feeds on its bodily fluids. Only when the worm grows to sexual maturity and decides it's had enough of this place do problems arise. Somehow it convinces the cricket to leap into the peril of a stream or pond. Because once the worm makes up its mind to leave, it punches a hole in the cricket's exoskeleton—peeking out just barely, but just enough—and in this way it can "taste" the water it seeks.

To test this, Hanelt came up with a brilliant experiment. He made cricket saline, mixing up a solution with the same salt content and chemicals that you'd find inside the insect, and dropped an infected cricket in. "The worms ultimately all came out very sluggishly," Hanelt says. "But they never made it, because they thought they were still inside the chamber of the cricket." But when he dropped this same cricket into regular old tap water, the worms in its belly tasted the difference and immediately erupted. And should you so desire, you can also go halfway and take a cricket and dunk it in water real quick. "If you then immediately pull it out, dab it off, the worms will go like spaghetti, shleeerp, straight back in," Hanelt says. "Because it's possible that the cricket is just moving around when it sprinkles or rains a little bit, and ultimately the worms need to have a mechanism to know that they're deep in water."

It's at this point I remember that the trough we found was filled with dozens of worms, yet somehow no crickets. Hanelt assures me that even being exposed to such trauma, and even though the worm can make up half its weight, a cricket may survive and escape watery doom. The things survive fine in Hanelt's lab, after all. In fact, even

though crickets typically harbor one worm, Hanelt was once able to infect a single cricket with over 30, all of which erupted en masse without killing their host. (Which, depending on your perspective on mercy killings, either weakens or strengthens my argument that nature is cruel.)

But a lab is no forest. What happened to those crickets? Did they merely snap out of it and scurry out of the trough? Or did birds make off with them? I ask because, again, we can't just consider our mind-controllers in a vacuum, but in a larger ecological context. Free meals of zombie cricket hordes could well transform how local birds structure their diets. And while no fish swam in that trough, for certain finned predators in certain river systems, kamikaze crickets make up a significant portion of their diet.

This is particularly true in Japan. Here, one study found that in five separate mountain stream systems, more than half of the trout population had crickets in their bellies—and crickets aren't supposed to be in rivers unless something has told them to be there. In fact, in the fall, the trout catch more wormy crickets by mass than any other prey item. Meaning first of all, clearly Japan's got a lot of little zombies hopping about. And two, these poor crickets are a tremendous resource for fish, to the point where the fish might require them to survive, like the Isle Royal wolves rely on worms to help bring down moose. So again, parasitic manipulations have consequences that ripple through the ecosystem.

Bring our view down from the macroscopic level to a microscopic one and we'll find that nematomorphs live a lifestyle—past all the business about wriggling out of other creatures' bodies—that couldn't be more different from our own. It's not just the brainwashing that's so bizarre, but an overall existence of peril locked in the prison of another animal, one in which the worm has to somehow extract enough energy from its host to keep itself alive, yet not so much that it drops the cricket dead.

3-The 'all-natural' label on your LaCroix is meaningless, but that doesn't mean it's bad for you

Reading the nutrition label on the back of a can of LaCroix sparkling water, you'll notice only two ingredients: "carbonated water," and "natural flavors." The company's rapid success, culminating in $827 million in sales last year, is due in part to its popularity as an all-natural beverage. Those claims are now coming under fire: a Chicago-based law firm has just filed a class action lawsuit against LaCroix, accusing the company of falsely branding its ingredients as "natural," when they are, in fact, identified by the FDA as "synthetic."

At least, that's how the argument goes. The truth is, this lawsuit seems to be a stretch, working on the ambiguous nature of how the FDA distinguishes natural chemicals from synthetic ones, and a product of alarmist, chemophobic ideas about what we put in our foods.

Beaumont Costales, the law firm that filed the suit against Natural Beverage Corporation (LaCroix's parent company), released a statement on Monday that said, "testing reveals that LaCroix contains a number of artificial ingredients… LaCroix in fact contains ingredients that have been identified by the Food and Drug Administration as synthetic. These chemicals include limonene, which can cause kidney toxicity and tumors; linalool propionate, which is used to treat cancer; and linalool, which is used in cockroach insecticide."

Those allegations sound nasty, suggesting the company is pulling a fast one on consumers and dumping some hazardous substances into those colorfully-decorated aluminum cans.

Neither Beaumont Costales nor LaCroix responded to inquiries when contacted, so it's unclear exactly how many ingredients the plaintiffs are claiming are falsely billed as natural. But even the three chemicals listed—limonene, linalool, and linalool propionate (better known as linalyl propionate)—don't exactly qualify as synthetic, and they're also not nearly as dangerous to consumers as Beaumont Costales' statement suggests.

Let's start with limonene. PubChem, the National Institute of Health's open database for chemical compounds, explicitly calls limonene a "naturally occurring chemical," and "a major component of oil extracted from citrus peels." Sounds pretty natural, right? As its name suggests, limonene is commonly used to give foods or other products a lemony flavor and fragrance.

And how about those claims that it's a harbinger of kidney toxicity and cancer? PubChem also states, "there is inadequate evidence in humans for the carcinogenicity of d-limonene." There is some evidence of male rats experiencing renal problems, including tumors, as a consequence of limonene exposure, but none of those findings (the vast majority of which were published in the early 1990s) have been properly reproduced in humans. Meanwhile, more recent studies suggest limonene is actually antagonistic to cancer.

Linalool is another additive used as a flavoring agent. It's "naturally occurring," found within many different types of flowers and spice plants, including mints, scented herbs, laurels, and cinnamon. It is most definitely used in insecticides as well—that part is true. But that doesn't mean it's poisonous to humans. After all, we don't ban chocolate just because dogs can't eat it. According to PubChem, the only real toxic effects linalool has been documented to inflict on humans are mild skin and eye irritation, namely from aerosolized forms of the chemical. That's a pretty normal effect for a spicy substance. And, coincidentally, it may also be another anticancer ingredient!

That leaves linalyl propionate, derived from plants like ginger and lavender, and another common flavoring and fragrance additive. It's been shown to help inhibit the proliferation of prostate cancer, at least in the form of Nagami kumquats. I'm honestly having a hard time trying to understand why the law firm decided "might actually be bad for cancer cells" would be an effective argument against LaCroix's ingredients.

Unless LaCroix is secretly 50 percent linalool (don't be too worried about that hypothetical; it would taste pretty gnarly) LaCroix drinkers have little to fear. According to Roger Clemens, an expert in food and regulatory science at the University of Southern California, it's worth remembering these three compounds are found in low levels in a long list of different types of foods and drinks in the U.S. "It is very unlikely these naturally-occurring substances pose a health risk when consumed at levels usually found in foods," he says. "If there were a health risk, then citrus juices and spices, such as curry, would not be consumed or be part of the commodity market."

Moreover, food ingredients aren't all of a sudden dangerous just because they have other, non-dietary uses. Casein, a primary protein in cow's milk, isn't making people sick just because it's also an adhesive ingredient in glues. If someone is arguing that a substance is bad by telling you that it's used in some poisonous product—as opposed to telling you how the exact substance in question is causing you harm—it's a good indication they're grasping at straws. Everything is made of chemicals; chemicals appear as ingredients in many things.

So if all of these substances are found naturally, why is Beaumont Costales claiming they're synthetic? That might have to do with the FDA's own documents. The agency's Title 21 lists both limonene and linalool under "synthetic flavoring

substances" that are "generally recognized as safe for their intended use," and lists linalyl proprionate under "synthetic flavoring substances and adjuvants" safe according to certain conditions. This is most likely the crux of the plaintiff's case.

That doesn't mean it's a good argument. According to the FDA, a "natural" ingredient that adds flavor to a food or drink must be from an animal or plant source. But those natural flavors could still contain ingredients that are artificial, such as preservatives. Even the agency's definitions of "natural" and "synthetic" are far from clear. The three chemicals discussed here can be derived naturally, but even if they are not (and we likely won't know until the case goes to court), they might simply be used as additives that are supposed to modify the natural flavor compound in some way.

Lastly, Clemens emphasizes, "the term '100 percent natural' does not have a statutory status within the U.S." It's a nebulous phrase that can mean whatever you want it to mean. LaCroix has its own interpretation, and just because that doesn't jive with what you initially thought doesn't necessarily mean it was fraudulent to consumers. "All-natural" labels exist solely to tempt you into buying stuff. They're all meaningless, so LaCroix is not unique in this regard. If you want all-natural water, you should stick with the tap (though your results may vary).

If you want to keep drinking LaCroix, ironically or otherwise, you should feel free to keep doing so, and resist getting caught up in alarmist, litigious scares. "Whether a substance is 'natural' or 'synthetic' should not be a health issue," says Clemens. "It's all about safety as assessed by experts in nutrition, food science, food toxicology, and medicine."

4-Megapixels A moth drinks tears from a bird's eye

It was close to midnight in the Brazilian rainforest when biologist Leandro Jo?o Carneiro de Lima Moraes spotted a small, grey and white bird resting in the understory. But the snoozing creature wasn't alone: a large brown moth clung to its neck, probing its eyeball with a long, sucking tongue.

A little under an hour later, Moraes came across another bird-moth pair. The bird, another Black-chinned Antbird, once again sat on its branch in a sleepy stupor as the erebid moth fluttered on the bird's neck and slurped its eye juices.

For the moths, this is a pretty standard night out. Biologists have spotted moths and butterflies drinking tears from mammals, turtles, and crocodiles. Bird eyeballs are a less common source of refreshment—Moraes is the first person to spot moths drinking bird tears in Brazil. Before now, there have only been a couple other accounts of moth-on-bird-eye action in Madagascar and Colombia.

Moths and butterflies use tear-feeding, officially known as lachryphagy, to help supplement their nutrition, as tears can be a good source of sodium and proteins. The insects drink tears for the same reason they congregate on mud puddles and slurp up useful minerals. There doesn't seem to be any harm or benefit for the birds. Although Moraes says he wonders whether the behavior increases the birds' chance of contracting an eye disease.

It's unclear whether moths rarely drink bird tears—or if humans just rarely catch them at it. It will take many more midnight excursions into the world's tropical forests to figure it out.

5-MEGAPIXELS For a technicolor nightmare, see this fish in high definition

Announcing all-new, high definition nightmares, brought to you by researchers at the University of Kansas, where biologists have developed new techniques to pose and image certain animals.

The ability to compare vertebrate skeletons in excruciating detail is important for anatomists and taxonomists who need to note minuscule differences for their research. Traditionally they've gone about this work by "staining" the bones with dyes, and "clearing" out most of the muscle tissue by dissolving it with a digestive enzyme. You wind up with a colorful but floppy specimen with see-through skin—ready for its close-up.

The new methods supercharge that process by creating the option to pose the creature. After a year of trial and error, a biologist-taxidermist duo cooked up a concoction of gelatin and glycerine that sets slowly enough to suspend your stained-and-cleared specimen in the gel and get your tools (and fingers) out of the way with time to spare. It's basically Jim Halpert's dream technology.

Arranging specimens freely will let biologists get clear shots of hard-to-photograph body parts (like the second pair of jaws at the back of a fish's throat), but that's only half the story. One of the dyes used to stain the animals shines bright red when exposed to certain types of light. "It fluoresces like a Grateful Dead poster," evolutionary biologist W. Leo Smith said in a press release. Photographs using normal light can blur fine features, but the red fluorescence produces sharp pictures that will, for better or for worse, etch every last detail into your memory. Sweet dreams!

6-Property Law – Rights of a Tenant

In this scenario, Raj has allowed his sister-in-law, Joyce, to live in his property. The question is whether Joyce enjoys the rights of a tenant, or if she is actually a mere licensee. There is, in English property law, a crucial distinction between the tenant and the licensee; the former enjoying significantly greater and more secure rights than the latter. It is often not, however, a clear cut distinction. In the present case, the terms of the occupation agreement that the parties drew up will need to be considered.

Firstly, the document itself needs to be considered. The first term of it expressly states that Joyce is living in Raj's house as a licensee, and not as a tenant or lessee (that is, that no lease has been created). The document itself, however, might well represent a contract, which would put Joyce in the position of a contractual licensee (following such cases as R v Tao (1977)). Even a contractual licensee, however, enjoys no proprietary interest in the property in question, as was evidenced in the case of Ashburn Anstaldt v Arnold (1989). A contractual licence can be contrasted to a bare licence, which is simply a personal permission, granted in this case by Raj to Joyce, without Joyce paying consideration, for her to enter his property. The purpose of the bare licence is to provide a defence against an allegation of trespass, so long as the licensee does not overstep the permission of the licence, as happened in the case of Tomlinson v Congleton Borough Council (2003). A contractual licence, by contrast, must involve (as in any contract) valuable consideration moving from the licensee. This was established by Megaw LJ in Horrocks v Forray (1976). Joyce pays a monthly rent of £600 to Raj, and this could well qualify as the consideration put the licence agreement on a contractual footing.

The second term of the occupation agreement states that Raj can nominate a third party to share the premises with Joyce. This relates to the issue of exclusive possession, which is an essential element of any lease or tenancy. This was described as "the proper touchstone" of a lease by Windeyer J in Radaich v Smith (1959). Two seminal cases highlighted this distinction between leases and licenses. In Street v Mountford (1985), Lord Templeman stated that a tenant is entitled "to keep out strangers and keep out the landlord unless the landlord is exercising limited rights reserved to him by the tenancy agreement to enter and view and repair." In AG Securities v Vaughan (1990), however, it was held that a licensee has "no legal title which will permit him to exclude other

persons". The agreement in the present case expressly allows for Raj to install a third party at his wish. This certainly argues strongly against anything other than a license governing the situation.

Certain factors, however, suggest that it is not such a simple case of Joyce being merely a licensee. She pays a periodic monthly rent of £600, and the occupation agreement states that she will live there for a fixed term of four years commencing 1 October 2005. To return to Street v Mountford (1985), the House of Lords, in that case, identified three inherent components of a lease or tenancy. The first was exclusive possession, which has been discussed already, and which is not apparently in evidence in this case. The second, however, is that the lease or tenancy must be granted for a fixed or periodic term certain. This means that the maximum duration of the lease or tenancy must be clearly ascertainable from the outset. Although the strict application of this rule was relaxed somewhat, the principle was reaffirmed in Prudential Assurance Co Ltd v London Residuary Board (1992). The 2005 agreement that granted Joyce the right to live in Raj's house clearly identified a term of four years after which the right would expire. In this respect, then, it would seem that the arrangement more closely resembles a lease. This is also a characteristic, however, of the contractual licence. The third element identified in Street v Mountford was the consideration that was discussed above. This too would suggest the arrangement is more akin to a lease, or at least a contractual licence, than a bare licence.

It seems, then, that although the arrangement shares some of the characteristics of a lease, the rights enjoyed by Joyce are, in fact, only those of the licensee; that is, a person whose presence is only grounded upon the personal permission of the licensor. Joyce's position is stronger than that of a bare licensee, however, by virtue of the contractual arrangement. A further blurring of the limits in this area exists between contractual licenses and equitable or estoppel-based license, which has increasingly become proprietorial in character. A contractual licence does not, however, confer any proprietorial interest on the licensee, as was illustrated in Cowell v Rosehill Racecourse Co Ltd (1937) by Latham CJ who stated that "fifty thousand people who pay to see a football match do not obtain fifty thousand interests in the football ground." A longer contractual licence, however, such as the one enjoyed by Joyce, for a period of four years, begins to resemble a proprietary interest in Raj's property, despite the absence of a right of exclusive possession.

It is in relation to this last area that the decisive factor is most relevant. That factor is that when determining whether Joyce's occupancy is a tenancy or a licence, the parties' intentions (which were clearly that a mere licence should be granted to Joyce) are largely irrelevant. In Aslan v Murphy (1990), the court found that its task was to "ascertain the true bargain between the parties". A crucial case of relevance to the present one was that of Addiscombe Garden Estates Limited v Crabbe (1958), in which an arrangement which purported to be a licence was in fact held to be a lease. Despite the fact that Raj and Joyce clearly intended the occupancy to be on the basis of a licence, and the contractual agreement was labelled as a licence, the court is at liberty to overturn this if the reality is that Joyce enjoys a lease. It seems unlikely, however, because of certain terms of the agreement, that Joyce enjoys a sufficient proprietorial interest in the property to become a lessee or tenant; but rather her position resembles that of a contractual (as opposed to a bare) licensee.

7-Case Analysis Freedom of Speech Law

Freedom of speech, association, political freedom and freedom of public places is common in most states and as such, many cases regarding these freedoms is common.

According to the first amendment in the US Bill of Rights, the people have the right to assemble and to free speech. The Supreme Court has therefore provided a list of public places and spaces that expressive activities of right to speech and right to assembly can take place(Henry, 2009). Enthusiastic fans of Big Bad Bruce are planning a gathering at the Baltimore airport to welcome the rock star home and to show support for his candidacy. The Department of transportation in Maryland state owns and controls the Baltimore airportdenies this group of fans permission to gather citing Section B ofairport's regulations that make it unlawful for any gathering that exceeds 30 people at any given time at the airport unless for travelling purposes.This paper discusses in details the basis of all challenges to Section B citing laws regarding public gatherings in airports in Baltimore, Maryland and the United States. This paper also explores the success chances of Big Bad Bruce's fans' regarding their permission to hold their welcome-home gathering for the rock star.

This paper begins with a case brief that gives a condensed and concise summary of the airport opinion and the legal rule of law that applies to the case. The paper then provides the case background including discussions of previously decided related cases using the actual court opinions of other legal cases and laws. The next section analyses the current and future implications of the case this section will discuss how the case is likely to affect current and future events and business laws using court opinions of other legal cases and publications. Also included in this case analysis research project is my personal opinion of the case. This will be based on legal rationale, principles, resources and other cases. The final section of this research paper will be the summary/conclusion of this case based on legal principles and facts. This paper examines how the Section B can be challenged based on the Federal laws and if the rock star's fans have chances for success in the lawsuit.

Case brief

This case analysis research paper is about Big Bad Bruce and his fans. The rock star is returning home to announce his running for a political office and 200 enthusiastic fans of Big Bad Bruce are planning a gathering at the Baltimore airport to welcome the rock star home and to show support for his candidacy. The enthusiastic fans of Big Bad Brucewere denied permission to gather at the Baltimore airport to welcome the rock star home and express their support for his candidacy. The gathering would involve 200 fans as well as a speech on political views by Bid Bad Bruce to the fans that will take 15 minutes. The Baltimore airport denied them permission for the gathering citing Section B of the airport regulations that technicallymake it unlawful for more than 30 people to gather anywhere in the airport unless they are gathering for travel related issues. According to the airport authorities, such a prohibition is intended to make the airport free of congestion and ensure that activities go uninterrupted (Maryland State Archives 2013). Following this decision, the fans are challenging Section B and want to gather at the airport in support of the rock star and welcome him home. The issues that arise in this case include whether Section B follows the First Amendment clause on regulations of the freedoms of speech, which includes political freedoms and freedom of association. Another issue that arises is whether Section B violates the First amendment.

Case background

Section B of Baltimore airport regulations prohibits any form of gathering of more than 30 people at the airport unless the gathering is travel related. In this case, several issues arise if the lawsuit goes to court. According to the first amendment of the US constitution, all fans that are US citizens have the freedom to speech including freedom of association and political freedoms. This means that the US government as well as

the state governments should and must adhere to this first amendment. However, the said governments may and can dictate time, place and other restrictions on the protected speech through the 14th amendment of the constitution. The welcome gathering and political speech that the fans of Big Bad Bruce want to hold is of this nature.

Saying so, the Department of Transportation in the stateregulates a public forum with reasonable time, space and other restrictions leaving an open end for communication regarding important government interests. Section B is however neutral as it is not specific to speech and so the rock star fans have the chance to challenge it as an overboard rule that allows no room for their speech related activity. Section B prohibits gathering outside the terminals and this makes the law unduly overboard as it restricts any form of gathering above 30 people anywhere in the airport. Some parts of the airport might be considered public forums but airports are generally held as not to be public forums even though they are property of the public. A similar case would be that of International Society for Krishna Consciousness (ISCON) v. Lee. In this case, the New York and New Jersey port authorities had put in place a regulation prohibiting solicitation of funds and distribution of literature at airport terminals. The ISCON alleged violation of the first amendment by the regulation(Stone, 1987).

On this basis, all public gatherings in the airport can be banned by the concerned authority, which is the Department of Transportation in Maryland, of which it can prohibit the use of the ground for any speech related activity. This will happen if the Section B's purpose is to ease congestion and promote smooth running of airport activities. There is no provision that enables a person to determine what conduct or activity is precisely prohibited. In this situation, the regulation is overboard as it forbids more conduct than what is considered necessary to achieve the main purpose of the regulation. A similar case would be that of Hague vs. CIO whereby a city official was allowed by an ordinance to decide whether an organization seeking to hold a gathering in public places in the city could do so. In this case, if the city official decided that the meeting would be a risk disturbance, then the request would have been rejected. The law in contention was also vague and overboard (Stone, 1987).

Analysis of Current Implications of Case

This case is challenging Section B in order to obtain access to the airport for the welcome-home gathering. It is also challenging the use of Section B as a means of contradicting the first amendment that guarantees freedom of speech including freedom of association and political freedom. The State of Maryland's Department of Transportation denied the groups of fans permission to have a public gathering at the airport. If the court upholds this decision, it is going to affect current issues and business laws in different ways. First of all, the first amendment prohibits the US government and the states government from forbidding assembly and speech by imposing putting restraints. In The Hague v. CIO case, the Supreme Court upheld the freedom to assemble by siding with the CIO with its intended activity of peaceably distributing literature and organizing labor meetings .The Supreme Court therefore ruled in the CIO favor showing that the city ordinance violated the First Amendment. The government may limit speech or assembly only when the speech or assembly has a compelling interest like presenting a potential harm to the general public(Van & William, 2003).

Section B tends to violate this law as it prohibits public gathering of the rock star fans as well as his intended public speech. A regulation that limits space, time and manner of assembly or speech may be allowed in some instances mostly in security instances. In the case of Big Bad Bruce's fans, Section B clearly violated the First Amendment

act by prohibiting public gathering anywhere in the airport. Even though airports are not considered public spaces, they are still spaces that the public own. Since the purpose of this law is mainly to decongest the airport and enable smooth running of activities and operations, the fans had the right to assemble as long as they did not cause congestion or interfere with smooth operations of the airport(Van & William, 2003).

8-Role of Research Design in Socio-Legal Research

Research is an organized, systematic and logical process of inquiry, using empirical information to answer questions or test hypotheses.[i] Research in common parlance refers to a search for knowledge.[ii] Research is a systematic and chronological effort of finding out a more appropriate solution to a common social problem.[iii] Research helps to push the frontiers of knowledge beyond horizon.[iv] The concept of research is thus closely linked with human endeavor for better understanding of his evolution, environment and growth through diverse stages of human history.[v] In a research, the most important being that the research problem should be researchable as well as manageable.[vi] All research is the collection of evidence or information for ascertaining an assumption or verifying some hypothesis. Research is a systemic attempt to push back the bonds of comprehension and seek beyond the horizons of our knowledge, some truth or some reality.[vii] The research is a critical and exhaustive investigation or experimentation having as its aims the revision of accepted conclusions in the light of newly discovered facts. In simple words, the research is any inquiry or search for fact or truth. Investigation of every kind which is based on original sources of knowledge may be said as research. Research is possible through observation of new facts and by the formulation of new thoughts and ideas.[viii] The aim or research is to find out the truth which is hidden and which has not been discovered so far. The purpose of research is to discover answers to questions by testing a hypothesis of a cause-effect relationship between variables through the application of scientific procedures. One of the objectives of research is to gain familiarity with a phenomenon or to achieve new insights to it.[ix] Research has become an integral part, not only of academic pursuits, but of all the areas of human activity.[x] Every field and every educational innovation is bolstered by research and innovation.[xi] Although research activities are primarily conducted by the government, university, industry or railway, the government is the main body which plans research in a country, finds funds for it and enables utilization of the results for the betterment of society.[xii] Thus, the term ‘Research’ refers to a critical, careful and exhaustive investigation or inquiry or experimentation or examination having as its aim the revision of accepted conclusions, in the light of newly discovered facts.[xiii]

The nature and content of research can barely be grasped without an appreciation of the method, we designate as scientific. Research, simply stated, is an endeavour to arrive at answers to intellectual and practical problems through the application of scientific methods to the knowable universe.[xiv] Method is the way of doing something methodology is the science or study of particular subject. The concept of the research methodology is much wider. The method a researcher follows in pursuing a research is research methodology.[xv] A system of models, procedures and techniques used to find the results of a research problem is called research methodology.[xvi] Research methodology is a systematised investigation to gain new knowledge about the phenomena or problems. But in its wider sense methodology, includes the philosophy and practice of the whole research process. It provides standards which the researchers use for integrating data and reaching

conclusions.[xvii] Legal phenomena requires their own research methodology. Such research methodology may be applicable to subjects of International or Muncipal laws, evaluation of Acts of different countries, implementation and consequences of Codes and Acts of different nations. The methodology of legal studies involves their own rules, interpretations and criteria for admissible explanations as well as research designs, data collecting techniques and data processing routines. The systematic investigation of problems and of matters concerned with law such as Codes, Acts, Constitutions, etc is legal research. Judges, Lawyers, Law Commissions and Researchers constantly do research in law. They do make systematic research into the social, political and other fact conditions which give rise to the individual rules, acts or codes.[xviii] Research may be pursued to obtain better knowledge and understanding of any problem of law, legal institutions in society, legal doctrines, legal philosophy, legal history, comparative study of law, or any system of positive law-International or Muncipal.[xix] Law is an instrument of social control. It originates and functions in a society and for society. In a planned development of the society, law is playing the role of a catalyst to help in the process of social change. Co-operative inter disciplinary research is required to deal with the socio-legal problems as socio-legal research is all interdisciplinary approach which extends into the fields of an social sciences. Upendra Baxi says that, the lawyer must know much of sociology and the sociologist must know much of law.

The Role of Research Design in Socio-Legal Research:

A research design is the conceptual structure within which research is conducted. It is the blueprint for the collection, measurement and analysis of data.[xxii] A research design is a plan comprising the researcher's decisions about the procedures of sampling, data collection and analysis of data in respect of a given study, which aims to fulfill the objects of the study. The process of working out a research design involves, making designs about the techniques to be employed for collection of relevant data, the safeguards to be employed to safeguard the validity, reliability and precision, the mode of drawing the sample, analyzing the data, interpreting the results. Through designing the research, the investigator achieves his research objective with the economy of amount, time and energy.[xxiii]

Meaning of Research Design:

Research design means the exact nature of the research work in a systematic manner. It involves the information about the research work in view of, framework of study, availability of various data, observations, analysis, sampling, etc. Research design includes the structure of research work.[xxiv] To design is to plan, that is , designing is the process of making decisions before the situation arises in which the decision has to be carried out. Designing is thus a process of deliberate anticipation directed towards bringing an expected situation under control. The socio-legal research guided either by desire to gain knowledge or by an urgency to solve a problem scientifically, works out a plan of study. While conducting inquiry one may anticipate various difficulties that may have to be encountered in the course of study and decide what to do under such circumstances. He records his decisions in advance. This type of logical and systematic planning to direct the research is called a research design.

9-Doctrine of Harmonious Construction

HISTORY

1st amendment came in the case of Sankari Prasad before SC. The court unanimously decided to resolve the conflict between Fundamental Rights and Directive Principles by placing the reliance of the line of doctrine of harmonious construction. The court

held that the FRs impose limitation over the legislature and executive power. They are not inviolable and parliament can amend them to bring in conformity to directive principles. The result was generally all law providing for the acquisition of state and interest therein and specially certain state including land reform acts of U.P., Bihar and M.P. were immune from the attack based on article 13 read with other provision of part III.

DOCRTINE OF HARMONIOUS CONSTRUCTION

It is a sound canon of interpretation that courts must try to avoid a conflict between the provisions of Statute. The rule of reconciliation on the Entries was propounded for the first time in the case of in re C.P. and Bare Act.

It is the province of the courts to determine the extent of the authority to deal with subjects falling within the legislative purview of each legislature. To avoid conflict, the Courts should read Entries of two Lists together and the language of one Entry can be interpreted, and modified too, with the help of another Entry. Interpreting Entries 24 and 25 of the State List harmoniously, the Supreme Court held that 'gas and gas works' being in Entry 25 would not fall in the general Entry 24'Industry' and observed: It is also well settled that widest amplitude should be given to the language of Entries but some of the entries in the different Listsâ€¦may overlap and sometimes may also appear to be in direct conflict with each other, it is then duty of this court to reconcile the entries and bring about harmony between them. In this way it may, in most cases, be found possible to arrive at a reasonable and practical construction of the language of the sections, so as to reconcile the respective powers they contain and to give effect to all of them. In Tika Ramji v. State of Uttar Pradesh, [3] the position of the industries was clarified by Supreme Court. In the instant case the vires of U.P. Sugarcane (Regulation of Supply and Purchase) Act, 1953 was involved. It was contended that sugarcane being 'controlled' industry fall within the jurisdiction of the Union List by virtue of Entry 52 of List I falls within the legislative purview of Parliament. The Supreme Court, therefore, had to explain the Inter-relation between Entries 52 of List I, 24 and 27 of List II and 33 of List III. Entry 24 of List II and 52 of List I establish that except 'controlled' industries, the industries generally fells within the State Sphere. Entry 27 of List II gives power to State to regulate the production, supply and distribution of 'goods' subject to provisions of Entry 33 of List III. The sugar industry being controlled industry, the distribution, supply and production of the product of this controlled industry viz. Sugar as a finished product,

Principle of Harmonious Construction

The principle of harmonious interpretation is similar to the idea of broad or purposive approach. The key to this method of constitutional interpretation is that provisions of the Constitution should be harmoniously interpreted. "Constitutional provisions should not be construed in isolation from all other parts of the Constitution, but should be construed as to harmonize with those other parts." A provision of the constitution must be construed and considered as part of the Constitution and it should be given a meaning and an application which does not lead to conflict with other Articles and which confirms with the Constitution's general scheme. When there are two provisions in a statute, which are in apparent conflict with each other, they should be interpreted such that effect can be given to both and that construction which renders either of them inoperative and useless should not be adopted except in the last resort. This principle is illustrated in the case of Raj Krishna vs Binod AIR 1954. In this case, two provisions of Representation of People Act, 1951, which were in apparent conflict were brought forth. Section 33 (2) says that a Government Servant can nominate or second a person in election but section 123(8) says that a Government Servant cannot assist any

candidate in election except by casting his vote. The Supreme Court observed that both these provisions should be harmoniously interpreted and held that a Government Servant was entitled to nominate or second a candidate seeking election in State Legislative assembly. This harmony can only be achieved if Section 123(8) is interpreted as giving the govt. servant the right to vote as well as to nominate or second a candidate and forbidding him to assist the candidate it any other manner. Upon looking at various cases, the following important aspects of this principle are evident – The courts must avoid a head on clash of seemingly contradicting provisions and they must construe the contradictory provisions so as to harmonize them. The provision of one section cannot be used to defeat the provision contained in another unless the court, despite all its effort, is unable to find a way to reconcile their differences. When it is impossible to completely reconcile the differences in contradictory provisions, the courts must interpret them in such as way so that effect is given to both the provisions as much as possible. Courts must also keep in mind that interpretation that reduces one provision to a useless number or a dead lumbar, is not harmonious construction. To harmonize is not to destroy any statutory provision or to render it otiose.

Case 1:

Unni Krishnan, J.P. and ors., etc. v. State of Andhra Pradesh and ors.

The writ petition was filed challenging whether the 'right to life' under Article 21 of the constitution guarantees a fundamental right to education to the citizens of India and right to education includes professional education. This was challenged by certain private professional educational institutions and also in respect of regulating capitation fees charged by such institutions. The Supreme Court held that right to basic education was implied by the fundamental right to life when read with article 41 of directive principle on education. As per article 45 of the constitution, the state is to provide free and compulsory education for all children below the age of 14 years and there is no fundamental right to education for a professional degree that flows from article 21. Several states have passed legislation making primary education compulsory and there is no central legislation to make elementary education compulsory. In addition, the Court held that, in order to treat a right as fundamental right, it is not necessary that it should be expressly stated as one in Part III of the Constitution: "the provisions of Part III and Part IV are supplementary and complementary to each other". The Court rejected that the rights reflected in the provisions of Part III are superior to the moral claims and aspirations reflected in the provisions of Part IV.

Case:2

Smt. Rani Kusum vs Smt. Kanchan Devi And Ors on 16 August, 2005

Showing the contexts in which harmonious construction author:A Pasayat appears in the document have to ascertain the object which is required to be served by this provision and its design and context in which it is enacted. The use of the word 'shall' is ordinarily indicative of mandatory nature of the provision but having regard to the context in which it is used or having regard to the intention of the legislation, the same can be construed as directory. The rule in question has to advance the cause of justice and not to defeat it. The rules of procedure are made to advance the cause of justice and not to defeat it. Construction of the rule or procedure which promotes justice and prevents miscarriage has to be preferred. The rules or procedure are handmaid of justice stress. In the present context, the strict interpretation would defeat justice.

In construing this provision, support can also be had from Order VIII Rule 10 which provides that where any party from whom a written statement is required under Rule 1 or Rule 9, fails to present the same within the time permitted or fixed by the Court,

the Court shall pronounce judgment against him, or make such other order in relation written statement under this provision, the Court has been given the discretion either to pronounce judgment against the defendant or make such other order in relation to suit as it thinks fit. In the context of the provision, despite use of the word 'shall', the court has been given the discretion to pronounce or not to pronounce the judgment against the defendant even if written statement is not filed and instead pass such order as it may think fit in relation to the suit. In construing the provision of Order VIII Rule 1 and Rule 10, the doctrine of harmonious construction is required to be applied. The effect would be that under Rule 10 of Order VIII, the court in its discretion would have power to allow the defendant to file written statement even after expiry of period of 90 days provided in Order VIII Rule 1. There is no restriction in Order VIII Rule 10 that after expiry of ninety days, further time cannot be granted. The Court has wide power to 'make such order in relation to the suit as it thinks fit'. Clearly, therefore, the provision of Order VIII Rule 1 providing for upper limit.

10-Contract Law Case Study of Hotel

Contract law involving a hotel and client A.

In this scenario, the first significant point is the nature of the parties' respective first dealings with one another. From the hotel's point of view, their first contact with A was through their advertisement on their website. This advertised the price of accommodation at the Scarborough Palms Hotel as being £300. From A's point of view, his first contact with the hotel is through an initial emailed enquiry. Although we are not told exactly what A's initial enquiry was concerned with, it is probable that it was simply asking for details of the offer.

In order to establish what the nature of the ultimate contract is, between the hotel and A, it is first necessary to find the 'offer' and 'acceptance'; the constituent parts of any contract. An offer has been held to be a statement which objectively (I.e. to a reasonable observer) indicates that the person making the 'offer' is prepared to contract on the terms specified in that offer (Gibson v Manchester City Council). It would at first sight, appear that the hotel's website and advert for the accommodation at the specified price was an offer. This, however, is not the case, as it has been held by the courts that advertisements are usually 'invitations to treat' rather than offers, as the advert usually lacks the other essential ingredient of a contract; an intention to be legally bound (Partridge v Crittenden). This principle is in place in order to protect the advertiser from incurring liability in contract to everyone who is willing to purchase the goods (in this case, the holiday), at the advertised price. An 'invitation to treat' is an invitation to the other party to negotiate the terms of a potential contract. A responds to this invitation by making his initial email enquiry, which can similarly be classed as an invitation to treat, or perhaps simply an enquiry. No offer has yet been made by either party (Fisher v Bell).

The hotel then respond to A's initial enquiry informing A of a special promotion that will entitle him to the accommodation at the price of £200. This communication will certainly be counted as an offer, as it displays an intention to be bound by the terms it mentions (a requirement that was first set out in the seminal case, Carlill v Carbolic Smoke Ball Co). A then 'accepts' the offer by filling in the online booking form. The hotel have stipulated a means of acceptance, by providing the online booking form which A is required to complete. This is, then, the hotel's prescribed method of acceptance. A, through no fault of his own, is unable to complete this prescribed method of acceptance, despite his attempt. It is uncertain whether this will affect his 'acceptance'. In Manchester Diocesan Council for Education v Commercial and

General Investments Ltd, it was held that the prescribed method of acceptance was not the only possible one, provided the other method was no less advantageous to the offeror. Unless the hotel specifically stated that the online booking form was the only method of acceptance, A's posting of a hard copy would be valid.

We come to the issue of communication of the acceptance to the offeror. Upon A's arrival at the hotel, he is informed that his booking form did not arrive, and that there are no available rooms. It is an established principle that an acceptance must be communicated to the offeror in order for their to be a contract (Holwell Securities Ltd v Hughes). In the present instance, however, the acceptance has been posted by A. Following Household Fire Insurance v Grant, the acceptance is effectively communicated on posting (the so called 'postal rule'). In order for this rule to apply, however, it must have been reasonable for A to use the post to accept the offer (Quenerduaine v Cole). In this instance, since the online booking form was not working, it seems likely that it would be found to have been a reasonable method of acceptance.

As of this point, then, the contract exists between A and the hotel. The terms of the contract specify that A will have accommodation at the hotel for the price of £200. He will later be able to claim damages for breach of contract from the hotel when they cannot furnish him with a room at that rate. Before that arises, however, there is a further contract which requires clarification. Upon A's arrival, and discovery that his booking form has not arrived, he threatens to sue the hotel. The manager's response is to make an offer of accommodation for £250. It is possible that subsequently, the hotel could claim the offer was made under undue influence. It is an established principle of contract law that where a contract is induced by undue pressure, it is voidable (Williams v Bayley). This means that if the hotel can establish that the manager made the offer under pressure, the agreement could be cancelled. A agrees to these terms, and a second contract exists between the parties. A then spend his holiday at the hotel and completes the second contract.

A subsequently claims for damages in the amount of £50. The hotel counter-claims for damages because A has breached the contractual term not to pursue an action against the hotel. These two claims, however, refer to two distinct contracts, and both, it would seem, are legitimate claims. It is possible that through forming the second contract, the equitable principle of waiver came into play. That is, by making the second contract, the parties (and A in particular), waived the right to claim damages (Hughes v Metropolitan Railway). There is also the possibility that by forming the second contract, the initial contract was frustrated, as it became impossible to carry out because the parties had subsequently contracted to the same agreement on different terms (Nickoll & Knight v Ashton Edridge & Co).

With regard to the second contract, the hotel are within their rights to claim damages for A's breach. He has clearly broken his contractual promise not to pursue an action against the hotel. There is a contract rule that a claimant cannot recover damages in respect of a loss which is too remote a consequence of the defendant's breach of contract. If the losses flow naturally from the breach, which in this case they would appear to, the losses are recoverable (Hadley v Baxendale). The hotel, then, will be able to recover damages for A's breach of the contract term subject, of course, to proving that this agreement was a term incorporated into the second contract.

11-Critical Discussion of Corporate Social responsibility

Corporate Social Responsibility Defined

Corporate social responsibility (CSR) is when a corporation exceeds statutory business standards (Johnson and Scholes 2008). CSR policies are relevant because they state what a company intends to achieve, in addition, to its statutory obligations. A corporation has to comply with legal standards such as employment contracts. However, a company can exceed those principles if it chooses to pay a 'living wage' rather than the minimum wage (Bloomer 2014).

Introduction to the Critical Discussion

The discussion will examine a traditional criticism of corporate social responsibility through the work of Friedman. This is a view which proponents of CSR will need to refute. The essay will then discuss how social and environmental responsibility can be reconciled, with profitability, using the work of Porter. The example of Hewlett Packard is discussed at length. This is because its policies emphasise how a multi-national company can achieve both environmental and social responsibility together with corporate profitability. The work of Handy is then considered. This argues that companies should have corporate objectives which are broader than just profitability and consider the purpose of the business.

Friedman's View of Corporate Social Responsibility

Friedman's view is a non-interventionist or laissez-faire vision of commerce. In his view business should aim to earn money while complying with "the basic rules of the society" such as paying taxes (Friedman 1970:1). It assumes that consumers are sovereign and are able to significantly influence corporate decision-making. This view of commercial organisations underplays the significance of consumer market failure. It is assumed that consumers can take their business elsewhere as Friedman believed that consumers can transfer their business to other producers (Friedman 1970). However, this is not possible if the consumer is unable to pay for another competitor firm's products. This is the case if a consumer were unable to pay for the safety features, offered by a car manufacturer such as Volvo, as discussed below. To summarise, socially responsible polices, can be seen as unrealistic if consumers are unwilling to pay for them.

Friedman argued that socially responsible business policies, such as promoting equality, can harm company performance. For example, Ben and Jerry's adopted a payment scheme where the highest paid employee could only earn "no more than five times the income of the lowest paid firm employee" (Barney and Hesterly 2010:7). This payment scheme made it difficult to recruit senior managerial talent to make sure that the company grew and remained profitable (Barney and Hesterly 2010).

A More Progressive View of Corporate Social Responsibility

There is an increasingly an expectation that companies will contribute to society to a greater extent than when Friedman was writing in the early 1970's. Companies operate in a social environment as well as an economic environment (Grant 2008). A firm's ability to survive depends upon its acceptability among consumers who give the firm 'social legitimacy' (Grant 2008:446). Examples of social awareness, such as a demand for safer cars, suggest that companies are wise to respond to consumer concerns (Grant 2008).Corporations have come under "increasing pressure to contribute to the societies … in which they operate and to adopt more socially responsible business practices" (Christodoulou and Patel 2013:467).

The corporate setting of voluntary objectives can be seen as an adequate response to the needs of society. Companies can set voluntary standards: to reduce the extent to which their actions cause negative externalities or side-effects (Barney and Hesterly 2010). For example, if a car manufacturer builds a car with a large number of safety features which more than comply with legal requirements. Volvo has promoted the

benefits of a “relatively safe car … which adds value that the customer is willing to pay a premium for” (Thompson and Martin 2005:95). However, this approach can also be seen as merely serving a premium segment of the market, rather than being particularly socially responsible. In this case, Volvo is taking a marketing position which conforms to sales objectives while offering better safety to the motorist (Johnson and Scholes 2008). Corporate social responsibility is only conforming to financial requirements.

Porter’s View on Corporate Social Responsibility and the Environment

The concept of CSR is useful as it can help reconcile the financial needs of business with say the safety needs of society. Porter argues that it is a mistake for business to see environmental legislation as a threat to be resisted (Porter and van de Linde 1995). Rather, socially responsible businesses can view regulation in a positive manner; that environmental regulation can be built upon to utilise resources more effectively. It is argued, that there are costs incurred with the elimination of environmental problems but that these are outweighed by the benefits, including financial savings and improvements to product quality (Thompson and Martin 2005). Therefore, it is possible for corporations to be socially responsible without compromising the financial status of the organisation. Porter’s argument is useful. It has allowed thoughtful companies, such as Hewlett Packard, to reconcile investment in environmental initiatives with corporate profitability.

The Hewlett Packard Report

Hewlett Packard has a strong reputation in terms of corporate social responsibility (thecro.com 2010). The company’s CSR policies are detailed and indicate a high level of social responsibility. For example, the company presents environmental information, in a proactive manner, with evidence of wanting to improve recycling programmes. It aims to improve environmental programs to reduce the waste from its production operations (Hewlett Packard 2011). Through these environmental initiatives, the company can help reduce business costs. Hewlett Packard’s CSR report discusses how it aims to extract value from products which are at the end of their product life (Hewlett Packard 2011). An example is the company’s commitment to re-manufacture its printer cartridges so that they can be used again. The company is attempting to promote a strong corporate responsibility through proactive environmental investment.

Hewlett Packard has demonstrated strong social responsibility policies. This suggests that such policies can be implemented on a large scale. The company has provided a significant amount of disclosure on a wide range of corporate areas from the environment to human resource management. The detail provided by Hewlett Packard is superior to other companies given that online trade publications have viewed Hewlett Packard’s performance favourably (thecro.com 2013). Given that Hewlett Packard was assessed favourably then the information provided, in its CSR report, can be interpreted as thorough and accurate.

The company attempts to improve the wider business community with measures to develop its external supply chain. The company aims for strong standards of behaviour outside the company’s core business. This suggests that it is attempting to improve working relationships with its component suppliers (Hewlett Packard 2011). Hewlett Packard’s CSR document conveys that the company is enabling social responsibility to be addressed. The company suggests that it has a grievance procedure so that different stakeholders can report social or ethical problems to senior management (Hewlett Packard 2011). The company is clearly investing in a responsible approach as it describes legal observance as an “absolute minimum” which it expects of different

stakeholders (Hewlett Packard 2011:82). They argue that their decision making achieves better employment standards, than laws in the different countries in which the company operates (Hewlett Packard 2011).

Concerns over Hewlett Packard's Stated Policies

Hewlett Packard attempts to make the company accountable, to external industry scrutiny. Procedures have been outlined which should make sure that ethical labour standards are achieved (Hewlett Packard 2011). The concern is that ethical objectives could be difficult to implement. There does not appear to be a specific example of how this guidance statement could be delivered in practice. However, there is a well structured diagram which outlines how the company will provide a "governance structure" so that the company can comply with ethical challenges (Hewlett Packard 2011:82).

Some of Hewlett Packard's environmental statements can be interpreted as platitudes. The company claims that that it wants to conserve more resources than it consumes (Hewlett Packard 2011). The concern is that it is easy to provide such statements. However, it is more difficult to assess how they are going to conserve more than they consume. This is because environmentally acceptable re-manufacturing programmes will still require energy consumption despite the conservation of the materials.

Hewlett Packard may have worse polices, in practice, than those conveyed by its report. This is because suppliers could be forced to comply with the company's standards. There are power relationships between dominant multi-national companies, such as Hewlett Packard, and their suppliers (Locke et. al. 2012). The international sourcing of computer components has left suppliers vulnerable to the dominant buying policies at Hewlett Packard (Wetherly et. al. 2011). These power relationships will tend to be overlooked, in corporate social responsibility reports, because companies will want to portray themselves in a favourable light.

Corporate social responsibility policies have been criticised. The development of CSR policies have been difficult to implement for many firms (Birchall and Cook 2006). However, these criticisms should, generally, not be directed at Hewlett Packard due to the level of detail contained in its CSR report. Arguably, they have made an honest corporate attempt to contribute to society (Porter and Kramer 2002). The report goes beyond the legal compliance advocated by Friedman. The detail provided is of a superior standard when compared to a minimum level of legal compliance.

The Business and Ethical Concepts of Handy

The work of Handy, arguably, goes beyond the corporate responsibility work of writers such as Porter. This is because Handy emphasises the importance of mission statements and the purpose of the organisation. Handy argues that "the purpose of a business . . . is not to make a profit, full stop. It is to make a profit so that the business can do something more or better. That 'something' becomes the real justification for the business" (Sage Publications 2015:15). Handy argues that a firm's profit should be the means to a larger end (Sage Publications 2015). There are companies which adhere to a deeper purpose than merely profit. Tradecraft, in the UK, would be a good example as the company's purpose is to operate "life-changing development projects" (Traidcraft 2015).

However, Traidcraft operates in a niche area of the retail market where affluent consumers, who are willing to pay higher prices, contribute to international development. Therefore Handy's ideas may have limited application to businesses throughout the whole of the United Kingdom. However, his ideas are useful where they can be applied. Tradecraft's mission moves beyond immediate stakeholders, such as owners and clearly considers the needs of the broader society (Dess et. al. 2010).

The company is an excellent example of a company which incorporates social and environmental, as well as financial factors, into its decision making (Dess et. al. 2010). The challenge for proponents of 'social responsibility' is that many retailers only undertake social and environmental policies which do not damage their sales and profits. Many retailers will concentrate on environmental responsibility in their stores, where they can achieve resource efficiency targets (Jones et. al. 2009). Many retailers' social responsibilities are guided by what they can achieve within their financial imperatives (Jones et. al. 2009). However, such corporate policies could lead to accusations of 'greenwashing'. In other words, that the retailers' commitment to the environment is limited and that social responsibility reports can play a public relations role rather than a social responsibility role. Many firms are engaging in 'greenwashing' to mislead consumers about the extent of their environmental activities (Delmas and Burbano 2011).

Conclusion

There is evidence of improvements to companies social responsibility polices. This is because firms have realised that it is financially prudent to use environment resources wisely. It is also necessary for business to be sustainable and to invest in good employment practices and proper labour standards. However, there is a concern that corporate social responsibility is limited by what the consumer is willing, or able, to pay for more ethical approaches. There are few examples of businesses which are willing to adopt socially responsible policies which affect their profitability. Ben and Jerry's is one example before its takeover by Unilever.

12-Impacts of Nuclear Energy on Global Business

Background and Overview

Tony Blair's Labour government has finally decided to move ahead "with a vengeance" (Webster, 2006) with its' plans for development of nuclear power, ending years of speculation on the issue.

Work on the last nuclear power station started eighteen years ago in the UK on Sizewell B and since then there has been a complete embargo on any fresh initiative in the area. Things are now likely to change, much to the concern of environmentalists and anti nuclear campaigners.

The use of nuclear power, for any reason, peaceful or otherwise, has always been looked upon with deep suspicion because of its inherent association with weapons of mass destruction and its ability to cause large scale destruction on a horrific and unimaginable scale. "Many analysts have attempted to explain the visceral hostility toward nuclear power, and the most common explanation is that people link nuclear power with nuclear weapons." (Lorenzini, 2005) The reasons for this attitude are also justifiable as most scientific work in atomic radiation, atomic change and nuclear fission, be it in the USA, Nazi Germany or communist Russia, at least till 1956, was focussed primarily on the furthering of the atomic bomb. It was only after 1956 that the focus of nuclear technology shifted to the design of safe and reliable nuclear plants. The growth in use of nuclear energy for power entered a state of not just stagnation but moderate decline, world wide, in the late seventies and remained so until the turn of the century and the UK was presumably, but echoing global concern in the formulation of its energy policy.

Very few reactors were ordered globally and the new reactors coming on line just about matched requirements. Global capacity increased by only a third in more than a decade. Even then, nuclear energy, from the 442 nuclear power reactors used in 31 countries, adds up to one sixth of the world's electricity supply today.

The growth of nuclear fuel as an energy source has been sluggish due to quite a few reasons, some of which now need rethinking in today's grim geopolitical and environmental scenario.

For more than three decades, energy policies in the United States and much of the Western world have been held in the ideological grip of a flawed concept: the notion that we can achieve sustainable energy by relying solely on conservation and renewable resources, such as wind, the sun, the tides, and organic materials like wood and crop waste. Born in the wake of the 1973 oil embargo and arising out of renewed commitments to environmental quality, this idea has an almost religious appeal. An unintended result is that the world has become ever more reliant on fossil fuels and therefore less able to respond to global warming. (Lorenzini, 2005)

It has been the case of the pro nuclear power lobby, for many years now, that nuclear energy is a clean, economic and efficient way to generate power; ideal for continuous generation of medium and large scale electricity. In nuclear power stations, apart from the nuclear reactors, the rest of the equipment works similarly to those in coal or gas fuelled power plants. However, the cheaper and more widely available fuel used by these nuclear plants, compared to those fired by coal, oil and gas, makes the case for its' wider use attractive. This is especially relevant today with oil hovering in the range of 70 to 73 USD per barrel, and gas from the North Sea wells beginning to run out. With the increase in greenhouse and emission problems and the uncertainty of fossil fuel supplies in a shifting and unstable political environment, the nuclear power option has definitely got itself a strong tailwind.

The concerns of the anti nuclear campaigners focus on a number of worrying issues. Their first contention concerns the forecasted reduction of carbon dioxide emission from nuclear power plants; this to them is no more than blatant propaganda.

In the US, where much of the world's uranium is enriched, including Australia's, the enrichment facility at Paducah, Kentucky, requires the electrical output of two 1000-megawatt coal-fired plants, which emit large quantities of carbon dioxide, the gas responsible for 50per cent of global warming. Also, this enrichment facility and another at Portsmouth, Ohio, release from leaky pipes 93per cent of the chlorofluorocarbon gas emitted yearly in the US. The production and release of CFC gas is now banned internationally by the Montreal Protocol because it is the main culprit responsible for stratospheric ozone depletion. But CFC is also a global warmer, 10,000 to 20,000 times more potent than carbon dioxide. (Caldicott, 2005)

In addition, the environmentalists say that nuclear fuel cycle also consumes large quantities of fossil fuel, in the mining of uranium, in the construction of the reactor and its' robotic decommissioning as also in the transportation and storage of radioactive waste.

The use of nuclear fuel can lead to significant health threats from the unregulated emission of radioactive isotopes; which include Krypton, Xenon, Argon and Tritium and could cause long term physical harm to residents in surrounding and nearby areas. These releases are unregulated because the nuclear industry considers these particular radioactive elements to be biologically inconsequential. The transportation and storage of radioactive waste could also become a global security problem, if the use of nuclear energy is adopted on a wide basis. A completely new and potentially catastrophic dimension would be added to global security with the deliberate creation of new and potentially vulnerable targets for terrorist strikes. While the advanced nations would be able to shore up reasonable levels of security the same may not be true of the developing countries where weaker management systems could lead to grave risks;

witness the variation in the effectiveness of different management systems in disaster control in the Chernobyl and Three Mile Island episodes.

Nuclear proliferation remains a major issue. The USA is planning to go ahead with the selling of weapons grade nuclear fuel to India, (a non signatory to the Nuclear Proliferation Treaty and a country with a history of surreptitious manufacture of nuclear weapons) for use in power generation. If it is India today, can Pakistan be far behind? The prospect of an atomic bomb capable Pakistan getting access to Yellow Cake, an intermediary for the production of enriched uranium, is a frightful thought; enough to send shivers down the spine of the developed world.

The energy crisis enveloping the globe has a number of dimensions, all equally worrying. The availability of fossil fuels is reducing sharply because of resource depletion, price spikes and geopolitical reasons. Greenhouse emissions of carbon dioxide are leading to global warming with far reaching ecological effects that could one day threaten the existence of the world. The development of renewable energy sources, wind and solar, once touted as the best solutions, have been largely unsuccessful and remained in the realm of experimentation; useful only in small isolated pockets.

In this situation, while nuclear energy does appear to have most of the answers, the concerns of the environmentalists and the anti nuclear campaigners also remain very valid.

2. Impact on Contemporary Business Organisations

The UK has always been in the forefront of development of nuclear technology. The work carried out by British scientists in the 1940s was renewed after the war and it is pertinent to recall that the world's first nuclear power reactor started in the UK in 1956. Twenty three nuclear reactors power the country's nuclear plants, leading to the generation of a total of 75 billion kWh of electricity, a fifth of the country's requirement. However, all but three of these plants are scheduled to close by 2020, with consequent effects on the economy and operations of contemporary business organisations.

The major dilemma for business and economy is to find alternative sources for energy, nuclear or otherwise to fill this expected gap in energy production and to provide for increased needs. 2020 is not so far away. The other major factor staring British economy in the face is the prospect of importing 90 % of its gas requirement by 2025. The country and its economy is looking at a huge energy deficit, an issue that will need resolution in the very near future.

The Confederation of British Industry (CBI) has, in a widely publicised call in April this year, asked the Government to clarify its' stand on longer term carbon emission policy to enable low carbon emission sources like nuclear fuel to play an important role. The CBI has also stated very categorically that nuclear power is the only proven low-carbon technology able to deliver consistent supplies of electricity on a large scale. The advantages of stable operating costs, the availability of nuclear fuel from politically stable countries and the ability to store uranium are practical reasons to work towards the development and commissioning of more nuclear plants. In addition, the operating costs of nuclear power are stable because the cost of fuel varies between only 5 and 10% of total operating costs.

The cost of building nuclear power plants, as of now, is far more than that of conventional oil, gas and coal fired plants. Operating costs are however not just lower but also expected to be stable and independent of recurring political upheavals. Two factors are however set to change these circumstances. The cost of fossil fuel, especially oil is on a sharp upward path, threatening to throw all cost projections out

of gear. The expected depletion in gas resource and consequent compulsion to buy increasing quantities from outside is also going to come with its own consequences, increased costs definitely one of them. While manufacturers of nuclear power plants are working on reduction of capital cost, a “significant increase in the price of natural gas could make new nuclear plants economically competitive even without further reductions in their capital costs.” (Taylor, 2004)

The CBI in its statement of April also stated that companies would seriously consider investing in new, capital intensive nuclear plants, subject to the introduction of a correct non-discriminatory policy on carbon emission; beyond the present policy which is unclear after 2012. Intense concern about the current situation also made it say that “an energy policy based on crossing fingers and the use of the prayer mat is not acceptable”.(Nuclear Power in the United Kingdom, 2006)

Contemporary businesses, not just in the UK but across the globe are wrestling with an energy crisis, the widespread usage of fast depleting fossil fuels, rocketing oil prices currently resting in the low 70s (USD per barrel), and the continuous spectre of carbon dioxide emissions and global warming.

The real advantage of nuclear energy is its potency. One pound of uranium contains the energy equivalent of roughly one million pounds of coal. Such potency means that nuclear power’s energy potential is vast, clearly sustainable as a long-term resource. It also means nuclear’s environmental impact is inherently low. With so much energy coming from such a small volume of material, producing nuclear fuel requires much less exploration, mining, transportation, and collection, with all their attendant environmental problems, than do fossil fuels. For example, a 1,000-megawatt nuclear plant requires one refueling per year, whereas a similarly sized coal plant requires 80 rail cars of coal per day. (Lorenzini, 2005)

The gridlock appears to be slowly tightening with nuclear power possibly the only solution to the intensifying problem.

3. Likely Future Scenario

The future scenario in use of fuel for energy and its development is probably going to move in reasonably predictable directions.

All across the globe, awareness on global warming and its possibly devastating repercussions has heightened considerably. Every natural calamity, be it the Tsunami in Indonesia, earthquakes in Pakistan, the arrival of the Katrina in the United States or the melting of the glaciers in the Himalayas finds an immediate media connection to carbon dioxide emissions, the greenhouse effect and global warming. This phenomenon, coupled with the instability of supply and the rising cost of fossil fuels is going to lead to an expansion of nuclear power both in the USA and the UK. Governmental restrictions on use of nuclear power are slowly being dismantled as governments across the globe see the advantages of going nuclear for power generation.

Along with increase in nuclear power generation, governments across continents will try to develop renewable energy sources for power generation. Renewable energy has not really made much headway despite concerted efforts in the last thirty years. Nearly 90 % of the global energy production is obtained from fossil sources and most of the rest comes from nuclear power. Wind and hydro energy can be harnessed only in suitable locations that have access to huge amounts of rainfall, fast flowing rivers or conditions suitable for setting up wind farms.

Countries with access to fossil fuels, oil, gas and coal will of course continue to depend heavily upon these sources for power. However, the threat of emissions and consequent ozone layer depletion will nudge all countries towards the development of

alternative sources. The rising costs of oil, essential for vehicular and air transportation will lead to its curtailment for use as as fuel for all but essential reasons.
Renewable sources will of course fill a part of the yawning power gap which appears to be looming on the horizon but nuclear power is also very much a part of the final answer. It is the one energy source that today combines the benefits of displacing the use of fossil fuels, minimising pressure on land, avoiding resource depletion and restricting harmful emissions.
The UK and the USA, both countries with over regulated nuclear power generation environments will necessarily open up their laws to ease the setting up of newer power facilities, based on nuclear fuels. The building of nuclear energy capacity necessarily comes with the enormous added responsibility of ensuring public health and safety, involving first, the storage and containment of harmful waste material and second, the prevention of dangerous nuclear material going into the hands of rogue states and terrorist organizations.
Contemporary business organisations will need to survive in similar circumstances for the next few years until additional nuclear and renewable energy facilities are set up. This is essentially going to be a slow, expensive and careful process and the period of infrastructure build up will be open to all the risks that exist today, namely uncertain supplies and skyrocketing prices.
It is only with the spread and extensive use of nuclear power on a global basis, the establishment and strict enforcement of protocols for responsible and peaceful use of nuclear energy and the rooting out of rogue states and terrorist organizations that businesses will be able to witness and take advantage of stability in supplies and cost of energy, free of the worry of a global environmental threat from emissions of harmful gases.

13-STA Travel Business Strategy

STA travel's primary aim is attract young and active as well as adventurous consumers anywhere around the world. A sensible business strategy might be to offer what the customer want when they need it, By operating more than 400 retail agencies around the world STA continues to take more risky environment and would planning to expand into new markets to further its reach in to the student travel world. As many of organizations, STA travel managers give the impression that upgrading or changing components of information system will positively impact a business strategy. Therefore it takes advantage to expand it market by developing staff training mechanisms on networking system and modernizing its electronic communication with their customers. STA provided "BLUEe" which is a single booking system pointed to every purchase in STA travel by offering features on network, infrastructure, finance and operating system. Furthermore STA make available to their customers a highly interactive website which attributing video reports STA customers about their travel destinations and freely downloading facilities the second life client or mainland as an advantage to becoming a playing member.
It is important to balance the strategy triangle. By making any changes in the information strategy or organization strategy in first then the triangle getting out of balance and will be have an effect on other involving areas too. By considering on that view point when STA building their virtual world they do changes in business strategy like making staff are more productive and making widest possible work place opportunities. As well as STA travel is trying to attract more customers by holding expensive resources, using expertise's knowledge and international programs in their

group service division. By building these changes they trying to make connection between managers and their travelers.
STA travel build a contract to develop their marketing attendance on second life through the computer simulated virtual world.
As a well run organization the business strategy of the STA makes the rest of the organizational and informational strategy is not appear a big different.
Organisation Strategy
When considering the STA travel organisation design, STA had grown-up and spread out its global reach through a chain of mergers. To responsive to their globally distributed and various cultural consumers that the STA organised around responsiveness and would be including elements of autonomy, empowerment and authority as close to the action as possible. If organisation needs to have responsive, it would not work to have centralized decision making authority. Because it takes long time to get information up and decisions back to the field. The travelling process organised through the market analysis and service histories. Also they do series of organisational process (such as STA travel second life, by building a virtual world) and make sure customers the STA travel is able to actually ready to provide their booking service when customer need their service.
STA designed web portal attract more travellers in to business and provide more information by downloading second life client software guide. From this second life web site STA travel offer their potential players to free download game and through the online the software connected to the grid computer servers and it is hosting one small area of many islands and the mainland.
The new organisation structure in STA is centralized and provide more flexible infrastructure. Accordingly it has most advantageous of environment for monitor and implement new process. STA travel implements shared services measurement for certain processes and functions. And also STA provide level of structure when they making any decisions.

14-Importance of Strategic Human Resource Management
The importance of Strategic Human Resource Management in organization: According to my understanding during the lecture period Human Resource Management Strategy as a central philosophy of the way that people in the organization are managed and the translation of this into HR policies and practices. To be affective, policies and practices need to be integrated so that they make a coherent whole that is integrated with the business or organizational strategy (Torrington and Hall)
Strategic Human Resource Management is the vital factor for an organization to achieve its strategic goals as it has increased in importance since 1980’s by considering the following factors which are discussed below:
Globalization is the current phenomenon of the world which has integrated all the business environments under one umbrella where Strategic Human Resource Management in only way to show the business what is the actual goals of that business. By its activities business organization can overcome global needs as SHRM learns organizations to sort out what is their positions and where they want to go in global business arena.
Government rules and regulations which are the important issues for organizations, because it affects the organizations, business activities, through its own policy and procedures. An organization which can be overcome these issues through its strategic

Human Resource policy, because organizations prepare its staffs, employees, stakeholders to be aware regarding these issues and do accordingly.
Knowledge and research based activities have impacted the organization dramatically in today's world, where Strategic Human Resource management helps the organization to nursing their Human Resource management accurately as well as make ready them to overcome future goals.
Labour unions which is the combined activities of Labours in the business that has affected the business strategic activities vigorously, but in this place, Strategic Human Resource Management gives treatments to them to be proactive and taking initiatives regarding labour's demand and benefits which help the organization to meet up the staffs problems. (According to my own understanding)
1.2 The purpose and contribution of Strategic Human Resource Management activities in an organization: Case Study ASDA
ASDA is one of the reputed retailer companies of WAL-MART which was formed in 1965 by a group of farmers from Yorkshire and its activities are still mainly based in the north of Britain. It expanded south in 70's and 80's , in 1989 buying rival change Gateways Superstores which is offering shoppers everything from Frank furthers to Diamond rings. ASDA is the second largest food seller that operates 370 stores from where primarily sell groceries and apparel, also the stores which are situated in different parts of the UK sell CDs, books, DVD's, House wear financial services, take away meal etc.
The Strategic Human Resource Management of ASDA which has developed its overall activities, because every year ASDA recruits 10,000 workers, 10,000 permanent staffs to work as little as 10 weeks a year. ASDA always targeted people over 50 and it has already employed 22,000 people aged over 50. For managing their SHRM ASDA's employees trainings is the highest in the market. Every year they recruit fresh trainee employee to build a proactive team for the management.
By this structure ASDA monitored and supervised all the activities while they ensure the power and position of that structure by its unique policy. For managing Strategic Human Resource Management ASDA assists organization to meet the needs of their employees in the best way they can, so that company goals can be promoted. It also managing people proactively, because it requires planning ways for ASDA to meet the needs of its employees, thinking ahead and also helping the employees to meet the needs of the organization. This process changes the outlook and affects the way things are done at this business site, in others words it help to integrate modern ideas and models into the traditional Human Resource practices to come up with better solutions which not only benefit the employees, but the organization. It helps the organization from the hiring of employees, to the training, assessment and discipline [http://www.mba-tutorials.com/human-resource-management/487-shrm-strategic-human-resource-management.html]

For proper employee management by ASDA it has affected the organization significantly, because ASDA be aware about the employees career and development resulting reducing time frame of recruitment and selection process, retention staff in the organization, creates the productivity of the employee by developing training programs. It also arranges career programs for the employee which builds the employees loyalty towards ASDA which gives them unique efforts to fight with competitors in the market.
Strategic Human Resource Management is the process of Human resource Management for a long period of time which helps organization to achieve its long

term goals. As a part of these activities ASDA maintains high standard of Human Resource Management through its unfair and competitive employees selection, motivation and training which given ASDA to be almost a market leader in the UK super market. It has established companies overall growth, revenue and satisfaction of stakeholders. (According to my understanding during the class period)

From the ASDA business site it is viewed that it has announced plans to create 9000 jobs in the UK through a mixture of new stores (20+new stores + extensions to existing stores), product range extensions in terms of non-food selling space named 'ASDA living' and others business expansion like home shopping, online shopping via-ASDA direct.

It sounds like an ambitious growth plan, although ASDA needs to keep growing quickly just to maintain its relative market share, where ASDA planed 179000 employees employ in the year. [http://tutor2u.net/blog/index.php/business-studies/comments/asd-goes-for-growth/]

President and CEO of Wal-Mart International, Dong McMillan thanked Andy Clarke for his leadership role in the development of the ASDA business during his times as president and CEO and in other roles during his 16 year career at the retailer "I am extremely proud of the management team at ASDA and the contribution that each of our nearly 170,000 colleagues makes every to serve our customer. We are very well positioned to continue to win in the UK market" [http://your.asda.com/2010/4/12]

From the discussion above it has been found that ASDA has been serve the customer promptly through their proactive management team which has impacted ASDA to improve its business growth revenue which attracts stakeholders such as employees, customers, suppliers, government, local community and competitors etc. Nowadays ASDA stakeholders feel confident as they invest as they could. Therefore, as a global company ASDA which is maintain its SHRM policies resulting to achieve overall growth of its business.

15-Strategic Alliances Reasons and Types

Strategic alliances and why are they formed

Strategic alliances can be seen as one of the fastest growing trends for business today; Alliances are sweeping through nearly every industry and are becoming an essential driver for their super growth. A strategic alliance, by definition, is a form of affiliation that involves a mutual sharing of resources for the benefit of all of the strategic partners. "Mutuality" is key (Beavers 2001). The business consideration is whether both alliance partners need each other. Strategic alliances range in size and scope from informal business relationships based on simple contracts to joint venture agreements, some times where corporations are set up to manage the alliance. According to Vyas et al (1995) strategic alliances are cropping up across the global arena mainly due to the maturation of several trends of the 1980s, such as: intensified foreign competition, shortened product life cycles, soaring cost of capital, including the cost of research and development, and ever-growing demand for new technologies. However, strategic alliances can be tricky. Partnerships foster mutual benefits, but the alliances exist only as long as they are advantageous to both parties. Research indicates that a high proportion of strategic alliances fail (Forbes 2002; Lorange and Roos 1991; Day 1995). This essay explores concept of strategic alliances drawing from Mintzberg et al's schools of strategy and then critically identifies the main factors that determine the design and delivery of effective co-operative strategies. It does so by using the case study that pertains to Avebe and Noveon Alliance.

Why?

For many multinational firms, strategic alliances have become increasingly important tools for ensuring speed and flexibility in carrying out multinational strategies. A typical example is SEVEL (Societa Europea Veicoli Leggeri), the 1978 strategic alliance between Fiat and Peugeot for the production of a new light van named Ducato. Both parties were short on resources and saved time and energy by combining their R&D and manufacturing efforts (Lorange and Roos 1991). Strategic alliances can be effective ways to diffuse new technologies rapidly, to enter a new market, to bypass governmental restrictions expeditiously, and/or to learn quickly from the leading firms in a given field

Mintzberg et al's Schools of Strategy

Strategic alliance is an agreement between two or more individuals, or entities, or organisations to cooperate in a specific business activity, so that each benefit from the strength of other and gains competitive advantage. The formulation of strategic alliance has been seen as a response to the globalisation and increasing uncertainty and complexity in the business environment. Strategic alliances involve the sharing of knowledge and expertise between the partners as well as in reducing the risk and costs in areas like relationship with the supplier and the development of new products and technologies. Strategic alliances usually make sense when the parties involved have complimentary strengths. Its unlike full-scale acquisition, an alliance does not give a firm total control over its partners.

Avebe and Noveon Alliance – Case Study.

Avebe, a Dutch company, established in 1919 as a joint sales organisation for the greater part of the Dutch independent potato starch industry. Through research and development, joint ventures and acquisition in Netherlands, Europe and Worldwide, Avebe now plays a major role in the global sales, marketing, production and development of potato starch and starch specialities used in food, pharmaceuticals, animal feed, textile, paper and adhesives. Avebe's specialities are used by the textile industry for obtaining good weaving efficiency, to obtain smooth fabrics, and for sharp and durable printing of fabrics.

Noveon, headquartered in Cleveland, Ohio with regional centers in Belgium and Hong-Kong, is a leading global producer and marketer of technology advanced speciality chemicals for a broad range consumer and industrial application. Noveon was recognised as leading producer of polymers. It was also acknowledged as the largest producer acrylic acid for synthetic polymer.

Reason for cooperation – Avebe

Avebe was outstanding in printing thickeners but not yet in reactive dye printing market. It was not possible for Avebe to enter into this market as it was purely a starch based industry. Only a combination of starch and synthetic polymer could help them enter this market. For this Avebe had two options- Noveon and Alloid Colloids (under ICI Corporation, England). Combination of Avebe's and Noveon's products in laboratory test showed excellent printing thickness for reactive printing dye market.

Reasons for cooperation – Noveon

Noveon's alliance with Avebe started by an accident. Noveon acquired QSI in South Carolina in 1994. QSI used to purchase natural starches from Avebe for its operation. This was the start of their joint venture. Synthetic polymer Noveon had was fairly expensive; while Avebe's natural starch was relatively cheap. They expected that blending of these two would result in better quality at reasonable price. Noveon expected that the price of synthetic and natural thickener blends would increase in US and Europe, due to the demand for high quality products. Combination of synthetic and natural thickeners could reduce the cost of dye stuff and chemicals. The saving

was estimated to be around $ 1 million per year. Noveon selected Avebe for their technology. Far East and Europe preferred Avebe as their best choice.

16-18th and 21st Amendments

It was explosively controversial, bringing out the haters and sparking a national conversation that totally dominated the media.

And depending on who you asked, it was either a bold experiment that dared to break new ground or it was a financial disaster. An awesome idea or an epic fail. An opportunity for women to finally show their stuff, or a slap in the face to a beloved cultural institution.

No, we're not talking about the Ghostbusters remake.

We're talking about Prohibition, the period in the U.S. between 1920 and 1933 when the 18th Amendment to the Constitution made it illegal to manufacture, sell, or import "intoxicating beverages" anywhere in the U.S. Yep, that all-American pastime—drinking beer, wine, and hard liquor—was soon to be illegal. After you drank up the stuff you already owned, if you wanted to drink, you had to violate the Constitution.

Let's back up, though.

Americans have always loved them some partying.

Colonial Americans drank early and often. By 1760, there were 60+ rum distilleries in Massachusetts and 22 just in Newport, Rhode Island, alone (source). Cowboys had their saloons, rich folks had their fancy private clubs, working guys had their neighborhood bars, college students had, well, anywhere they could think of. Forget baseball—drinking was the real national pastime.

So what made Americans decide to turn off the tap?

Lots of things, it turns out. In the early 1800s, as the result of a religious revival that swept the country, social reformers and evangelical Christians decided it was time to get serious about the dangerous effects of drunkenness on society and the family. Women were tired of having their lives ruined by husbands who spent their paychecks on whiskey instead of food and rent. Temperance societies sprung up around the country, preaching—wait for it—temperance (moderation) in the use of alcohol. Alcoholism came to be seen as a major public health issue.

The Temperance Movement was a mad success. In 1851, Maine went "dry," followed soon after by twelve other states. Prohibitionists formed the ultimate single-issue political party, The Prohibition Party; a politician was either "wet" or "dry," and it had absolutely nothing to do with how recently they'd gotten out of the bathtub.

Except for a brief intermission for the Civil War, the Prohibition movement gained steam through the turn of the century thanks to a coalition of different groups that all hated alcohol for their own reasons. Women saw Prohibition as part of the march of social progress that included universal suffrage and equal access to education and the professions. Industrialists like Henry Ford thought that a sober workforce might be more productive. Colleges saw the benefits of non-hungover students. Even the KKK and the Communists came out in favor of Prohibition.

Starting with local and state governments, the politically savvy Anti-Saloon League threw the support of its voting bloc behind dry candidates. More states went dry. The League decided to go big: no less than a Constitutional amendment to smack down demon rum once and for all.

The final piece of the puzzle dropped into place in 1913 with the passage of the 16th Amendment creating a federal income tax. Up until then, 40% of federal revenue came from liquor taxes. (Did we mention Americans loved to drink?) With the new tax, Prohibition wouldn't break the bank.

A Prohibition resolution was put before Congress and passed. By the beginning of 1919, the required number of states ratified the shiny new 18th Amendment. Then everyone stopped drinking and the country entered a new golden age.
Just kidding.
Problem was, Prohibition was impossible to enforce. One Detroit newspaperman said, "It was absolutely impossible to get a drink...unless you walked at least ten feet and told the busy bartender what you wanted in a voice loud enough for him to hear you above the uproar" (source).
Making alcohol illegal gave criminal groups an instantly valuable product that could make them, like, all the cash. Gangsters like Al Capone made a fortune manufacturing, importing, and selling liquor. With all that money on the line, gang violence escalated to insane levels, and law enforcement either couldn't keep up or were in the pockets of the gangs and looked the other way.
By the late-1920s, public sentiment turned against Prohibition. The stock market crash of 1929 and subsequent Great Depression didn't help. People had to deal with the misery of financial ruin without the help of the occasional beer, and all those alcohol tax dollars started looking pretty good to a panicked government.
In 1932, Franklin D. Roosevelt campaigned at least partially on a platform of repealing the 18th Amendment. By early 1933, the 21st Amendment was on the table, and its only job was getting rid of the 18th. When Utah became the 36th state to ratify the Amendment (giving Congress the required 3/4 of states), what President Herbert Hoover had called the "noble experiment" with Prohibition was over.

17-Missouri Compromise
Once upon a time, a long time ago, there was a young democracy that had just come into the world and was looking to prove itself as the face of a new age of liberty and equality. It was named America, and it was full of the high idealism of independence, apple pie, and bald eagle-patterned boxer shorts. This young upstart was looking towards a bright future—a move away from the dated oppression of the Old World monarchies and the construction of that classic, shining City on a Hill.
It was a nice fairy tale…if you were a wealthy, white land-owning male.
For everyone else, it was a bunch of nice-sounding ideas that translated to life being more or less unchanged between British and American rule. (Cue the sad trombone noise.)
In 1819 the U.S. was growing out of its diapers into a toddlerdom that included, rather than screetching requests for more Froot Loops and endless repetitions of Row, Row, Row Your Boat, the Manifest Destiny drive westward. The U.S. was a very advanced toddler.
Immigrants continued to come over in droves, and people were settling further and further west, until those settlements became cities, and then those cities started thinking "Hey, I want a piece of the Federal Government pie," and applied for statehood. And this was all well and good for the most part, with everyone just trying to get their own slice of the beta-testing American Dream.
But then Missouri came along and mucked it up for just about everyone.
See, there was a problem with all of this, and it was a problem that the U.S. had been putting off since the earliest proposals of its federal government. To no surprise to anyone with a knowledge of Things That Were Super Messed Up In American History, that problem was slavery.
Enslaving People Is Despicable And Morally Corrupt, You Say?

Lots of (good) people were uncomfortable with slavery, lots of people didn't care, and lots of people made all sorts of crazy rationalizations as to why owning another human being was perfectly moral so long as that human being wasn't white. It was the hot button issue of its day, and to say it was divisive is an understatement comparable to saying "Mount Everest Is A Pretty Tall Hill."

Basically the entire economy of the South hinged on the institution of slavery, so even if you found the idea of slavery morally repellant—well, you didn't have a whole lot of choice in the matter if you wanted to maintain the status quo.

Ultimately, that was all the Missouri Compromise was about. Nobody wanted to rock the boat, nobody wanted to be that guy who accidentally destroyed the Union by forcing the slavery issue. Nobody was ready for that conversation to happen. Well, except the slaves of course. They had rather understandably passionate ideas about what these rich old white dudes could do with their status quo, and just exactly where they could shove it.

But slaves couldn't vote, and only legally constituted 60% of a person anyway. Wow. History sure is depressing.

So onto this stage of eggshells entered Missouri, eager to become the twenty-third state. Up until this point, there had been a sort of equilibrium that had formed between Northern non-slave holding states and Southern slavery states. But Alabama had just been allowed to enter the Union, and so adding Missouri was seen as unfairly tipping the scales towards the pro-slavery faction.

Tiptoeing Around The Issue

Let's be clear that it wasn't outright stated in these terms. Anti-slavery groups said that new states didn't have the same self-determination rights as the older states, and so were subject to laws passed by these older states. Pro-slavery folks claimed that every state had the right of self-determination. These were all theoretical arguments employed in order to dance around the issue: everybody knew what this was about.

But coming out in the open and just discussing it like that? Why, they might even have to confront the issue! No, U.S. legislators decided. Better we just sort of try to work this out, and let the next Congress deal with this whole "slavery" business.

So they did—rather than address the issue at heart, the Northern and Southern powers sought a compromise.

This proved to be quite a bit more difficult than you might imagine, but there was one powerful asset on the side of the status quo, and his name was Henry Clay. Clay at the time of the Missouri Compromise was nearing the peak of one of the most successful (and slimy) political careers in U.S. history.

18-Homestead Act

Okay—it was more like land for $10 in filing fees and five years of backbreaking work…but that just doesn’t have the same ring to it.

But still: the Homestead Act was giving away tracts of land for super-cheap. If you were brave enough to take the plunge, you could "Go West, young man," and get your homestead on.

Here's a super-condensed history lesson: 1862, the Republican Party was newly in power with an agenda dead set against expanding slavery into the West. (Lincoln’s Republican Party was actually more in line with our Democratic Party, while modern Republicans are more like Democrats of Lincoln’s time.) (Source)

And President Lincoln & Co. were ecstatic to get a chance to make America the land of the yeoman farmer (a.k.a. independent small landowners). But don’t think the

Homestead Act was in any way non-political. The legislation was actually a big raspberry blown in the face of the newly formed Confederacy.
See, it's the history behind the Homestead Act that makes it more than just a way to move the population around and set the stage for the ’90s nostalgia masterpiece Oregon Trail. It boils down to control and fear of change: all that land lying around was at the center of a serious game of tug-o-war between the abolitionist and industrial North and the pro-slavery and agricultural South.
The western territories were like an axe hanging over the head of the slave states. Any shift in the balance toward more free states would hurt their chances of keeping their slaves. This resulted in a lot of time spent blocking any government action toward the Homestead Act before 1861. After that, the Southern states said, "Peace out" (but without the peace part), and formed the Confederacy…which led to the Homestead Act being passed and the biggest game of land-grab ever began.
And we’re not talking about small bits of land here and there—we’re talking plots of land across Ohio, Washington, Illinois, California, Indiana, Louisiana, Michigan, Alabama, Wisconsin, Florida…well, it’d be faster to list what wasn’t included.
This was totally revolutionary.
Also revolutionary? The Homestead Act allowed women, immigrants, and freed slaves to own land. The very careful use of "person" and "individual" make it beyond clear that the government had to respect any person brave enough to try their luck at homesteading. That was crazy progressive.
Sure, there were plenty of downsides to the Homestead Act. It totally discounted the fact that Native Americans were already on the land out West (a running theme in American history) and the success rate of homesteaders was only 40 percent.
But it's known today as a document that both a) was the legal doctrine equivalent of flipping the bird at the Confederacy and b) stated that anyone, regardless of race, gender, or original nationality, had a right to build a home on the range.

19-The Hypocrisy of American Slavery
Frederick Douglass was the celebrity speaker at the 1852 Independence Day celebrations in Rochester, New York. Think of it like PBS' A Capitol Fourth—but without the washed-up celebrities—because on July 4th, 1852, Douglass was a prime headliner.
If his listeners were expecting a "God Bless America" pep rally, they got something entirely different. Instead, Douglass took the opportunity to throw serious sarcastic shade at the whole room. And we're guessing you have a hunch about the topic.
"The Hypocrisy of American Slavery" is only one of dozens of speeches Douglass gave on the topic of slavery. In fact, he emerged as the leading African American figure of the 19th century largely because of his way with words—not only through his speaking, but also through his writing.
In the speech, Douglass contrasts white citizens' experience of the Fourth of July (which was the 19th-century equivalent of sparklers, strawberry shortcake, foam Lady Liberty crowns) versus enslaved people's experience of the Fourth of July (um, that of righteous anger at being enslaved).
Here is Douglass' main point: don't expect slaves to be really excited about your liberty. In fact, stop patting yourselves on the back and thinking you're so special because of that one time you declared independence from Great Britain. If you really cared about liberty, you'd be doing a whole lot more to end slavery in the United States.
Douglass had escaped slavery in Maryland 14 years earlier, and in those 14 years, he had become a respected anti-slavery speaker and writer. His first autobiography,

Narrative of the Life of Frederick Douglass, was published in 1845, and when he gave this speech, he was also publishing an abolitionist newspaper called Frederick Douglass' Paper, which indicates not that he was kind of narcissistic but that he had sufficient name recognition to sell a paper on his name alone. (Douglass knew how to build a personal brand before personal branding was cool.)

Douglass repackaged "The Hypocrisy of American Slavery," added some extras, and gave it again the next day as "What to the Slave Is the Fourth of July?"

Hey, the guy knew a powerful speech when he saw—er, delivered—it. Contrasting the celebration of the United States' Independence Day with the uncomfortable fact of ongoing slavery was pure rhetorical gold.

And it still is, even today. Time selected it as one of the "Top 10 Greatest Speeches," alongside others from the likes of Socrates, Winston Churchill, and Martin Luther King Jr. (You know that you're a big-deal orator when you're sharing company with heavyweights like them.)

20-Four Freedoms Speech

Be Afraid. Be Very Afraid.

Have you ever tried to convince someone to do something they don't want to do? Like, say, convince a cat that a bath is actually kind of a good idea considering it's covered in mud? Or reason with a two-year-old about why eating Play-Doh is actually not such a hot plan of action? Or get your mom to stop trying to rearrange your hair?

It's rough.

Now, imagine upgrading that scenario to a much bigger scale...a much, much bigger scale. Imagine being the president of the United States trying to convince the American people (all of them) to do something like pay more taxes or get involved in a world war—you know, presidential things. Big deal things.

Sounds daunting, right?

Well, if anyone knew how to be convincing, it was President Franklin D. Roosevelt, who was daunted by very little. Persuading people to tackle unpleasant tasks was something FDR successfully did again and again. The guy was president four times in a row, after all.

In his 1941 "Annual Message to Congress on the State of the Union," otherwise known as the "Four Freedoms" speech, FDR expresses his concern for the future prosperity and safety of America.

Why? Well, it's kind of a funny story. (And by "funny story," we mean "terrifying moment in history.")

World War II was going full bore. Germany was sweeping across Europe and gobbling up as much of the continent as it could. On the other side of the world, Japan was making a mess in China, to say the very least.

Understandably, FDR was concerned that one of the aggressor countries—specifically Germany—would set its sights on taking down America. They probably wanted all those amber waves of grain for brewing beer.

Worried about a possible attack on the United States, FDR needed everyone to understand the seriousness of the situation. So, he took the opportunity to use his 1941 State of the Union address to persuade the American people and Congress that they, too, should be very concerned about this possibility—concerned enough to act.

Those Nazis Aren't Playing Around, Guys

In his speech, he argues that, as dictators waged war on democratic nations, they were waging war on the very nature of democracy itself. For FDR, an assault on democracy

anywhere was an assault on democracy everywhere, including and especially America's democracy.
The purpose of FDR's speech is to urge the nation to come together and be prepared to fight for the future. He is urging the United States to prepare like never before for an invasion that might or might not be coming. However, in doing so, he is careful not to paint a picture of a scary war-torn world to come…because that might simply freak people out.
Instead, he leaves his audience with a description of the glorious global freedom that would result from America's righteous defense of itself and of democracy.
This future of liberty and justice would be based on a set of democratic principles that FDR articulates as the Four Freedoms:
Freedom of speech and expression...everywhere!
Freedom of religion...everywhere!
Freedom from want (which means freedom from suffering for lack of things like food, shelter, clothing, security, and other basic quality-of-life things)...everywhere!
Freedom from fear (by which FDR specifically means fear of military aggression from other nations)...everywhere!
We told you he was convincing, didn't we?
World War II has come and gone, with victory for America and the Allies, but struggles for human rights grievously continue to this day. For many, FDR's four principles of democracy are more relevant than ever.
Now that's an important legacy for—or should we say "four"?—you. FDR FTW.
Fear Factor
This speech came out of the same mouth that gave us the immortal line "the only thing we have to fear is fear itself."
And we're not just lobbing that at you because we love FDR quotes (although we do), but because it seems like FDR loved fear. Maybe it's because he was so fearless himself. Maybe he just liked watching people squirm. Either way, he didn't shy away from using it as a great motivator.
Relying on his examination of trials and tribulations that quite literally span a couple of centuries, FDR gives his audience ample opportunity to imagine all the horrors of war that had happened, that were happening, and that could happen.
That's scarier than imagining Freddy Krueger and Michael Myers made a baby together and named it Jigsaw.
And, as a testament to the strength of his rhetorical skills and the lasting effects of World War II, we're still able to imagine situations that could have taken place…had the war unfolded differently.
The United States of Axis-erica? No, Thanks.
So, let's do it. Imagine what might have happened if the Axis had won.
First of all, the United States might be an isolated non-superpower split between Germany and Japan—carved up between them like a big ol' sheet cake. Not so bad, you say? You like apple strudel and wasabi-flavored Kit Kats, you say?
That's just the tip of the dystopian iceberg.
The impact of an Axis victory would have drastically changed the face of the globe and radically rerouted history. The Axis could have been the first to control and deploy atomic weapons—just imagine Hitler with his finger on the big red button. The same kind of genocide committed by Axis powers could have occurred in America. So could the same kind of suppression of rights. The list goes on…and it's truly wake-up-in-the-middle-of-the-night-screaming frightening.

FDR pitches the American public on the importance of preparedness and vigilance. And, if he hadn't done such a good job of getting people mobilized, the United States might have been in a lot worse shape when war finally came a-knocking. For example, the blow of Japan's surprise strike on Pearl Harbor, an attack that dragged the United States fully into World War II, would have sunk more than a slew of ships.
Instead, the country was ready and raring to unleash the beast.
Ultimately, FDR's "Four Freedoms" speech was a wake-up call delivered close to home and one for which we can all, basically, be thankful.

21-Sleep and cognition in children
We all know that lack of sleep makes us more prone to attentional failures, more likely to make mistakes, makes new information harder to learn, old information harder to retrieve ... We all know that, right? And yet, so many of us still go to bed too late to get the sleep we need to function well. Of course, some of us go to sleep early enough, we just can't get to sleep fast enough, or are prone to waking in the night. (Personally, I can count the times I've slept through the night without waking in the last fifteen years on my fingers).
I talk about the effect of sleep on memory elsewhere; I want to talk here about a sleep problem that we don't tend to think about so much — the sleep deficit children are running.
A survey commissioned by the National Sleep Foundation found that 3-to-6-year-olds in the U.S. get about 10.4 hours sleep nightly, while experts recommend 11 to 13 hours. 1st graders to 5th graders who should be getting 10 to 11 hours are averaging just 9.5 hours.
And a study of middle-school children (11 to 14 year olds) found a direct correlation between sleep deprivation and depression, lower self-esteem, and lower grades. "The fewer hours of sleep that children got, the more depressed they were, the higher number of depressive symptoms [they had], and the lower their self-esteem and the lower their grades."
The second largest growth spurt occurs during these years (usually 10-14 for girls; 11-16 for boys), so this is a time when a lot of sleep is needed. But it's also a time when children become more capable and more independent; when they're likely to start taking on a lot more activities, work harder and longer, and are monitored less by their parents and caregivers. So ... it's not surprising, when we stop and think about it, that a lot of these children are starting to pick up the bad habits of their parents — not getting enough sleep.
Which also points, in part, to the solution: if you're a parent, remember that your children are, as always, modeling themselves on you. And sleep habits usually reflect a household pattern. If you're a teacher, remember you need to educate the family, not just the child.
The National Institutes of Health (NIH) have identified adolescents and young adults (ages 12 to 25 years) as a population at high risk for problem sleepiness based on "evidence that the prevalence of problem sleepiness is high and increasing with particularly serious consequences."
Sleep disturbance in infants and young children has also been found to be associated with lower cognitive performance. Previous studies have looked at the severe end of the spectrum of sleep disorders — obstructive sleep apnea. More alarmingly, a new study of 205 5-year-old children found even mild sleep-disordered breathing symptoms (frequent snoring, loud or noisy breathing during sleep) were associated with poorer executive function and memory skills and lower general intelligence.

Before you panic, please note that some 30% of the participants had SBD symptoms, so it's hardly uncommon (although there may have been a bias towards children with these symptoms; it does seem surprisingly high). You might also like to note that I personally had a blocked nose my entire childhood (always breathed through my mouth, and yes, of course I snored) and it didn't stop me being top of the class, so ...
Nor is the research yet developed enough to know precisely what the connection is between SBD and cognitive impairment. However, it does seem that, if something can be done about the problem, it is probably worth doing (in my case, taking me off dairy would probably have fixed the problem! but of course noone had any idea of such factors back then).

22-Biological clocks and memory

I've always been interested in the body's clocks — and one of the most interesting things is that it is clocks, in the plural. It appears the main clock is located in a part of the brain structure called the hypothalamus (a very important structure in the brain, although not one of much importance to learning and memory). The part of the hypothalamus that regulates time is called the suprachiasmatic nuclei. These cells contain genes that switch on, off, and on again over a 24-hour period, and send electrical pulses and hormones through the body. This is the body's master clock.
But it is not the only clock in the body. Each organ in the body uses the time signal from the master clock to set its own clock. As a consequence, different systems in the body operate on different schedules. Thus blood pressure peaks at one particular time of the day, and levels of the stress hormone cortisol rise and fall in accordance with the clock that governs this.
The effect of this is that certain physical disorders are more likely to occur at particular times, and, more significantly, that certain medications may be far more effective at certain times.
What does all this have to do with learning and memory?
Well, not a whole lot of research has been done on the effects of time of day on cognitive performance, but what has been done is reasonably consistent. It seems clear that, for many people (but not all), there are significant time of day effects. The most reliable is that, in general, teenagers and young adults perform best (mentally) in the afternoon, while older adults (seniors) perform best in the morning.
Having said that, let's qualify it a little.
Let's start with a table. Now, this represents the findings of one study [4], so let's not get carried away with the illusion of precision cast by actual numbers. Nevertheless, it is interesting. These percentages represent the preferences reported by the young and old participants in the study. These preferences correlated with improved performance on a memory test.
Now the first thing to note is how marked the differences are between young and old. Of particular interest is how many of the younger adults had no preference. Compare this with that of older adults. The second finding of particular note is how pronounced the preference for the morning is in older adults — 83% preferred morning. And, most interesting of all, is a finding from another study by the same researchers [5]: when tested at their preferred time, older adults performed comparably to younger adults on a memory task. Younger adults, by contrast, seem able to perform well at all times.
There is also some evidence [3] that the deleterious effect of interference (the intrusion of irrelevant words, objects, events) is worse for older adults at those times of day when their performance is poorer. Older adults are more vulnerable to interference than younger adults.

The findings for teenagers and young adults may also apply to children. One study [2] found that below-grade-level students who received reading instruction in the afternoon improved their performance more than those students who received instruction in the morning.
But it must always be remembered that this general principle that morning is better for the aged, and afternoon better for the young, does not apply to each and every individual. As the table tells us, time of day affects some people more than others, and time preference is an individual matter, not entirely predicted by age. This is underscored by a study [1] that found improved performance when students were taught at times that matched their preferences. There was also some evidence that, for some students at least, achievement was greater when they were taught during their teacher's ideal time of day.
None of this is an argument that you should resign yourself to learning only at your preferred time of day! But you could use the information to modify your strategies. For example, by scheduling difficult work for your optimal time (assuming you have an optimal time, and are not one of those fortunate people who have no strong preference). You can also try and counteract the effect by, for example, drinking coffee during your nonoptimal time of day (this was found to be effective in one study with older adults [6]).

23-Eating right for your brain
Although I'm a cognitive psychologist and consequently think that memory and cognition is mostly about your mastery of effective strategies, when it comes to age-related cognitive decline, I'm a big believer in the importance of diet and exercise. But while we know these things can play an important role in why some people develop cognitive impairment and even dementia as they age, and others don't, we don't yet know with any great certainty exactly what exercise programs would be the best use of our time, and what diet would have the most benefit.
The role of diet in fighting age-related cognitive decline is quite complex. Many older people have inadequate diets, partly no doubt because of the shrinking in appetite and perhaps the dulling of taste and smell. It seems to me, for example (and this is purely a casual observation), that sweet foods tend to be appreciated more by the elderly, while other flavors are less able to be appreciated. The problem with the shrinking appetite is that it becomes even more vital, if the quantity of food is much reduced, that the nutritional quality is good. The less you eat, the less you can afford to eat "empty calories". Everything must count.
Other factors concern the need to fight declining physical health. Cardiovascular problems, cholesterol problems, blood pressure problems, inflammation — all these have been implicated in contributing to cognitive decline. Therefore any diet that helps you fight these problems is also helping you fight cognitive decline.
A recent Swedish study tackled the inflammation problem. The study, involving 44 overweight people aged 50-75, found that after four weeks eating foods presumed to reduce low-grade inflammation, bad (LDL) cholesterol was reduced by 33%, blood triglycerides by 14%, blood pressure by 8% and a risk marker for blood clots by 26%. Memory and cognitive function was also improved (but no details on that were reported, and at present it appears only a press release is available — no academic paper).
The diet was high in antioxidants, low-GI foods (i.e. slow release carbohydrates), omega fatty acids, wholegrain products, probiotics and viscous dietary fibre. Examples of foods eaten were oily fish, barley, soy protein, blueberries, almonds, cinnamon,

vinegar and a certain type of wholegrain bread. Some of the products are not yet available in the shops, but were developed specifically for the study.
Another study, involving 712 New Yorkers, found that those who most closely followed a Mediterranean-like diet over a six-year period, were 36% less likely to have brain infarcts compared to those who were least following the diet. Such a diet has also been associated with a lower risk of Alzheimer's disease.
The Mediterranean diet includes high intake of vegetables, legumes, fruits, cereals, fish and monounsaturated fatty acids such as olive oil; low intake of saturated fatty acids, dairy products, meat and poultry; and mild to moderate amounts of alcohol.
And an 11-year study of over 3800 seniors found that those who adhered more closely to an anti-hypertension diet (DASH) maintained their cognitive performance better over time, and that this appeared due to intake of four food groups: vegetables, whole grains, low-fat dairy, nut/legumes.
Other studies have pointed to the importance of maintaining blood sugar levels.(These studies, with the exception of the Swedish study, are all ones that have been previously reported on this site.)
We can be fairly sure that fighting inflammation, hypertension, and so on, help us fend off cognitive decline and impairment in our senior years. We can also be reasonably sure that fruit and vegetables are good for us. No one's arguing much about fish either (although you do have to consider the toxicity of the fish, especially mercury load). There's a messy ground however over the whole carbohydrate, sugar, fat, protein, dairy ground.
Recently I read a very interesting article reviewing a new book called Good Calories, Bad Calories. In this book, the author apparently "dispels nearly every belief doctors and the public health community hold to be true about nutrition and health". According to the blogger, "It would be easy to dismiss his claims, except that he makes his case not with theories and conjectures, but through a meticulous review of the nutrition and medical literature going back a hundred years." Moreover, the claims do help explain some of the more puzzling quandaries about the rise of obesity.
They also, I have to say, fit in with my own experience.
The basic tenet of the book is that it is carbohydrates, and most especially refined carbohydrates, that are to blame for our current epidemics of obesity, diabetes, coronary heart disease, and even cancer. We should avoid anything made with flour, cereals, potatoes, and anything with a lot of sugar (bananas, I'm afraid, are also a no-no). We don't, on the other hand, need to worry about meat, dairy, or fat.
This is, in fact, exactly what I have found in my own struggles with weight (although of course my reason for discussing this here is not weight per se but more fundamental physical problems). When my weight climbed to what I regarded as appalling levels, I lost the desired 20kg through a rigorous low-carbohydrate diet (although my reasons actually had more to do with trying to work through my food sensitivities). And when I say low-carbohydrate, I was actually living mainly on fruit and vegetables. I did find, after a while, that the lack of carbohydrate created an energy problem, but a quarter-cup (uncooked) of brown rice every day fixed that. When, after a couple of years, I loosened up on my diet, having some bread (gluten-free; yeast-free!), the occasional bit of baking, the occasional small bit of potato … well, my weight immediately started climbing again. I complain that I only have to look at some baking to add weight!
I'm fully conscious that this wouldn't be everyone's experience — I live with three males, all of whom are the tall, lean type, who can eat vast quantities of baking without it apparently having any effect. But this is my point. I think the author of this book makes some good points about the difficulties of diet research, and he may well be

right in his recommendations. But even when we get to the point when we can be certain of what is a “healthy diet”, it’s still not going to be true for everyone.
So my advice to individuals is that you don’t take the disputes among health and nutrition experts as an excuse for eating what you like, but instead as a basis for exploration. Look at the various diets for which there is some evidence, and work out which ones work for you. Which will depend not only on your genetic makeup, but most particularly on the damage you’ve already done to your body (not pointing a finger! We’ve all damaged our bodies just by living). As a reminder of which I was interested to read an interesting article in the New York Times on the high-fat diet recommended for epileptics.

24-Improving attention through nature

Until recent times, attention has always been quite a mysterious faculty. We’ve never doubted attention mattered, but it’s only in the past few years that we’ve appreciated how absolutely central it is for all aspects of cognition, from perception to memory. The rise in our awareness of its importance has come in the wake of, and in parallel with, our understanding of working memory, for the two work hand-in-hand.
In December 2008, I reported on an intriguing study (go down to "Previous study")that demonstrated the value of a walk in the fresh air for a weary brain. The study involved two experiments in which researchers found memory performance and attention spans improved by 20% after people spent an hour interacting with nature. There are two important aspects to this finding: the first is that this effect was achieved by walking in the botanical gardens, but not by walking along main streets; the second — far less predictable, and far more astonishing — was that this benefit was also achieved by looking at photos of nature (versus looking at photos of urban settings).
Now, most of us can appreciate that a walk in a natural setting will clear a foggy brain, and that this is better than walking busy streets — even if we have no clear understanding of why that should be. But the idea that the same benefit can accrue merely from sitting in a room and looking at pictures of natural settings seems bizarre. Why on earth should that help?
Well, there’s a theory. Attention, as we all know, even if we haven’t articulated it, has two components (three if you count general arousal). These two components, or aspects, of attention are involuntary or captured attention, and voluntary or directed attention. The first of these is exemplified by the situation when you hear a loud noise, or someone claps you on the shoulder. These are events that grab your attention. The second is the sort you have control over, the attention you focus on your environment, your work, your book. This is the type of attention we need, and find so much more elusive as we get older.
Directed attention has two components to it: the direct control you exert, and the inhibition you apply to distracting events, to block them out. As I’ve said on a number of occasions, it is this ability to block out distraction that is particularly affected by age, and is now thought to be one of the major reasons for age-related cognitive impairment.
Now, this study managed to isolate the particular aspects of attention that benefitted from interacting with nature. The participants were tested on three aspects: alerting, orienting, and executive control. Alerting is about being sensitive to incoming stimuli, and was tested by comparing performance on trials in which the participant was warned by a cue that a trial was about to begin, and trials where no warning was given.

Alerting, then, is related to arousal — it's general, not specifically helpful about directing your attention.
Orienting, on the other hand, is selective. To test this, some trials were initiated by a spatial cue directing the participant's attention to the part of the screen in which the stimulus (an arrow indicating direction) would appear.
Executive control also has something to do with directed attention, but it is about resolving conflict between stimuli. It was tested through trials in which three arrows were displayed, sometimes all pointing in the same direction, other times having the distracter arrows pointing in the opposite direction to the target arrow. So this measures how well you can ignore distraction.
So this is where the findings get particularly interesting: it seems that looking at pictures of nature benefitted executive control, but not alerting or orienting.
Why? Well, attention restoration theory posits that a natural environment gives your attentional abilities a chance to rest and restore themselves, because there are few elements that capture your attention and few requirements for directed attention. This is more obvious when you are actually present in these environments; it's obvious that on a busy city street there will be far more things demanding your attention.
The fact that the same effect is evident even when you're looking at pictures echoes, perhaps, recent findings that the same parts of the brain are activated when we're reading about something or watching it or doing it ourselves. It's another reminder that we live in our brains, not the world. (It does conjure up another intriguing notion: does the extent to which pictures are effective correlate with how imaginative the person is?)
It's worth noting that mood also improved when the study participants walked in the park rather than along the streets, but this didn't appear to be a factor in their improved cognitive performance; however, the degree to which they felt mentally refreshed did correlate with their performance. Confirming these results, mood wasn't affected by viewing pictures of nature, but participants did report that such pictures were significantly more refreshing and enjoyable.
Now, I've just reported on a new study that seems to me to bear on this issue. The study compared brain activity when participants looked at images of the beach and the motorway. The researchers chose these contrasting images because they are associated with very similar sounds (the roar of waves is acoustically very similar to the roar of traffic), while varying markedly in the feelings evoked. The beach scenes evoke a feeling of tranquility; the motorway scenes do not.
I should note that the purpose of the researchers was to look at how a feeling (a sense of tranquility) could be evoked by visual and auditory features of the environment. They do not refer to the earlier work that I have been discussing, and the connection I am making between the two is entirely my own speculation.
But it seems to me that the findings of this study do provide some confirmation for the findings of the earlier study, and furthermore suggest that such natural scenes, whether because of the tranquility they evoke or their relatively low attention-demanding nature or some other reason, may improve attention by increasing synchronization between relevant brain regions.
I'd like to see these studies extended to older adults (both of them were small, and both involved young adults), and also to personality variables (do some individuals benefit more from such a strategy than others? Does reflect particular personality attributes?).
I note that another study found reduced connectivity in the default mode network in older adults. The default mode network may be thought of as where your mind goes when it's not thinking of anything in particular; the medial prefrontal cortex is part of

the default mode network, and this is one of the reasons it was a focus of the most recent study.
In other words, perhaps natural scenes refresh the brain by activating the default mode network, in a particularly effective way, allowing your brain to subsequently return to action ("task-positive network") with renewed vigor (i.e. nicely synchronized brainwaves).
Interestingly, another study has found a genetic component to default-mode connectivity (aberrant DMN connectivity is implicated in a number of disorders). It would be nice to see some research into the effect of natural scenes on attention in people who vary in this attribute.
Meditation is of course another restorative strategy, and I'd also like to see a head-to-head comparison of these two strategies. But in any case, bottom-line, these results do suggest an easy way of restoring fading attention, and because of the specific aspect of attention that is being helped, it suggests that the strategy may be of particular benefit to older adults. I would be interested to hear from any older adults who try it out.

25-Benefits of herbs & spices for cognition
There hasn't been a lot of research into the effects of herbs and spices on cognition and the brain, unfortunately. But on the positive side, the risk of side-effects is very low, so we don't need a lot of evidence for it to be worth trying.
Spices
Probably the most researched of these substances is the curry spice turmeric, more specifically one of its components, called curcumin. This has been found to be a powerful antioxidant and anti-inflammatory, which affects the brain protein BDNF (involved in the creation of new neurons). Research also suggests it may be protective against amyloid plaques, and so help fight Alzheimer's.
These findings have had an effect on my own cooking — I habitually cook up a lot of vegetables in the wok for our evening meal, and I add turmeric to the mix (heating it, along with some other curry spices, in the oil before adding the veges), so I have turmeric most days. Cumin, by the way, is (notwithstanding the similarity in names) something completely different.
Another spice that may be helpful, and one that is even easier to add to your daily diet, is cinnamon. I've been happily generous with cinnamon on my breakfast ever since the first hints came out that cinnamon might help protect against Alzheimer's (it's not like it's an ordeal to add cinnamon!). Now we have more evidence, with a finding that two compounds found in cinnamon —cinnamaldehyde and epicatechin — appear to help prevent tau tangles (one of the characteristics of Alzheimer's).
Herbs
As for herbs, there's a researcher in Britain who takes an interest in herbs, and it's really solely down to him and his students that we have any idea about the effects of herbs on cognition. Because they're all from one lab, and because the studies are invariably quite small, and the issue difficult to study, we can't put too much weight on these findings. But, as I say, where's the harm?
Four herbs have been put forward as helpful for the brain. Sage and lemon balm seem to increase the activity of acetylcholine, and so may be helpful to protect against Alzheimer's. They have also been linked to better cognitive performance. The scent of rosemary (i.e. from essential oil) has also been linked to better cognition, as has drinking peppermint tea.

From a more indirect perspective, chamomile tea and the scent of lavender have both been linked to feelings of calmness, which might help those who suffer from sleep problems. Lemon balm has also been linked to greater feelings of calmness.

26-Food & Supplements

A perennial topic in the arena of memory improvement is the question of "food for the brain", and in particular, whether there are dietary supplements that can improve your mental abilities. While my own emphasis is improvement through development and practice of skills, I don't dismiss the possibility of improvement through more physical means. I myself am a great fan of the "you are what you eat" principle. This is mainly because I suffer from multiple food sensitivities, so the consequences of food are very much a reality for me. That doesn't mean I believe perfectly healthy people should obsess about their diet. There is another principle that is of great importance: we are all individuals.

For example, a year ago, I wrote of the effects of caffeine on memory, concluding that: "while caffeine may help older adults in the later part of the day, those with hypertension, diabetes, impaired glucose tolerance, or high homocysteine levels, would be wiser to avoid coffee, even if decaffeinated. In general, while caffeine may help you overcome factors that lower your cognitive performance, it does not seem that caffeine has any significant direct effect on memory, although it may well help you pay attention."

So, caffeine is more helpful for some types of people than others, and is in fact contra-indicated for some. Moreover, the effects are different for those who are accustomed to a high caffeine intake, compared to those who only occasionally consume caffeine. And – here's the real kicker – I also know from personal experience that the effects of caffeine are highly individual: I myself respond to caffeine not with the usual increased alertness, but in fact with decreased alertness. It makes me sleepy!

I do think there are physical factors of far greater importance than diet. Sleep is the obvious one. Individual differences don't show up in the basic need to have enough sleep, and the right sort of sleep, to optimize brain functioning, but they do of course show up as regards how much sleep is right for us. That also, is something that changes with age, and, I imagine, health, throughout our lifespan.

Another physical factor which should be given due weight is exercise. While its effect is not as great as sleep (I don't think anything rivals the importance of sleep!), I would give it more importance than diet because its effect is far more consistent. I don't think anyone would fail to benefit mentally from increased physical fitness (which is not to say there isn't a level of fitness beyond which no more mental improvement will occur).

Diet, on the other hand, depends a great deal on the individual. There is little evidence that dietary supplements or changes to the diet improve mental function in those who don't suffer from any of the conditions which can adversely affect brain function — e.g., aging, physical disorders, depression, stress, etc.

In other words, if you are a relatively young person with no health problems, I suggest you concentrate on getting enough sleep and exercise, and learning and practicing effective memory strategies.

If you have any conditions which can adversely affect brain function I would also emphasize doing this! But, additionally, I do think there are foods and supplements you can take which may well significantly improve your brain function.

Which ones? Here we enter the area of individual difference. To find out what is effective for you, you should start with the research. What foods and supplements have been demonstrated to be effective in improving cognition?

Here we enter an area fraught with difficulty. News reports come out about foods and supplements all the time, and today's world is filled with people hawking "health" products. How do we know what to believe?

The first thing, of course, is to ascertain whether the claims are backed up by research. But that's not as easy as it sounds, because every seller of such products knows the importance of sounding as if research has proven the effectiveness of their product. (Actually, I automatically disavow any text which talks of research "proving" something. No researcher worth his salt would ever make such a claim.)

How do we determine the genuineness and reliability of the research? First, and most importantly, by assessing the source. For example, I only cite research from reputable academic journals, or academic conferences. I also give greater weight to research from researchers whose work I know of. Hopefully, by so doing, I also make myself a reliable source.

This is not, however, infallible, for even well-respected journals can make mistakes. For example, very topically, the truthfulness of a widely reported study of a nutritional supplement's effects on thinking and memory in the elderly has recently been cast into doubt (actually, this is a rather polite phrase for the comments now being made: "scientists who reviewed the paper had found the methods and statistical findings so unlikely that they wondered whether the study had actually been done"; "The statistics were not just implausible, they were impossible.")

Nevertheless, the very shock with which these questions are being raised demonstrates that, by and large, the system does work. We cannot expect certainty.

Having approved the source, the second thing to consider is the extent to which the research has been replicated. One study does not make an answer! It is indicative only. It is interesting.

Even a second study is little more than another support. Before we can say, "You know, I really think there's something to this", we need a number of studies building together from different angles.

So, a study showing that sage can help cognitive function in healthy young adults (there is indeed such a study) is interesting. Given that sage is easy to grow, and commonly consumed (one doesn't need to worry about toxicity), I would go so far as to say, give it a try! But I wouldn't give a lot of weight to the research until more studies had been carried out. (I would, however, happily drink sage tea everyday on the off chance, except it turns out – I really can't believe this! – I'm sensitive to sage, too.)

On the other hand, for a product that is expensive, or has potential side-effects, I would wait for more evidence to come in before trying it. Okay, we've looked at the research, we've found the foods and supplements of potential benefit. What next?

Next, you look at your own particular problems.

For example, my main problem is food sensitivities. The first, most dramatic, thing I did to overcome my increasing mental sluggishness was: stop eating foods which turned out to be bad for me! After concentrating on that for a year or two, with my physical and mental problems much improved (but not gone), I turned my attention to the damage done to my body over the long period during which I was unaware of my food sensitivities. I now take B12, which I am sure has had a significant effect on my brain, and have recently started taking iron (as a woman of childbearing age). I also take other mineral supplements, principally to overcome deficiencies in my environment (New Zealand's soil is deficient in a number of minerals), and lecithin (partly because of the deficiencies in my diet as a result of having to avoid certain foods).

The final step, once you've established the possible foods and supplements which are worth trying, is to see whether they are effective for you. Remember me and the coffee. What works for one doesn't necessarily work for another (and may indeed be harmful). But don't try everything at once! One at a time, and the most likely first.
So, what foods and supplements might be of benefit to your brain?
Most of the research into the cognitive benefits of diet and supplements has been concerned with seniors, with alleviating the effects of age on the brain. This is consistent with the belief that there is little, if any, benefit to be gained by young, healthy adults. Having said that, however, the following have been shown to be of benefit in at least one study:

creatine
sage
lemon balm
a diet high in soy products

Remember my comment about the reliability of single studies! However, since three of these four are all perfectly "natural" food items, there would be little danger in trying these out.
Several substances are worth mentioning as having been of particular interest to researchers for their potential benefits to brains suffering from the effects of age:

gingko biloba
ginseng
choline (lecithin)
vitamin B12
phosphatidylserine (PS)
acetyl-L-carnitine (ALC)
antioxidants (particularly vitamin E)

27-Benefits of fruit & vegetables for cognition

Fruit & vegetables are a vital part of a brain-healthy diet. Apart from valuable vitamins and minerals, they contain antioxidants which help protect against damage to brain cells, as well as helping with cholesterol and blood flow.

Color is your best sign that the fruit or vegetable has more 'goodness': go for reds and purples and dark greens.
I don't think anyone's going to try arguing that fruit and vegetables are not good for your health! We know they're good. But that's just general "oh, I know it's good for me" — do you know that the benefits are not only for your general health, your protection against obesity and diabetes, cancer and heart disease, but also for your brain. Actually, there's two aspects to this. An unhealthy diet (one rich in junk food, in saturated fat and sugar) is actively bad for your brain, and (the right) healthy diet is actively good for your brain.
Fruit and vegetables are only one part of a brain-healthy diet, of course, but they're a very important part. A major reason for this benefit is thought to lie in the antioxidants present in these foods. Antioxidants help fight the oxidative stress that increasingly damages our brain cells as we age. Antioxidants is a group term, and some that fall into this category are more important than others.
The anthocyanins appear to be the most useful — these are responsible for the reds, purples, and blues in some plants. Several studies have affirmed the cognitive benefits of blueberries and Concord grape juice in particular (Concord grapes are especially purple grapes). Basically, the darker the fruit, the more anthocyanins, and the more powerful it will be.

Other valuable compounds include pterostilbene (found in blueberries), and resveratrol (found in grapes and red wine), which lower cholesterol. Quercetin (found in apples, blueberries, and cranberries) protects against cell damage and apparently helps with blood flow.
All of this perhaps explains why it is so much better to eat well rather than hope to receive what you need from dietary supplements!
Of the vegetables, green leafy vegetables, especially spinach, have been found to be especially beneficial. Onions are also a good source of quercetin (and presumably red onions, like red apples, are better than their paler cousins).
As a rule of thumb, the best fruits and vegetables are those with the most color. And, obviously, it's the color you want to eat (so no peeling your nice red apple!).

28-Diabetes - its role in cognitive impairment and dementia
There was an alarming article recently in the Guardian newspaper. It said that in the UK, diabetes is now nearly four times as common as all forms of cancer combined. Some 3.6 million people in the UK are thought to have type 2 diabetes (2.8 are diagnosed, but there's thought to be a large number undiagnosed) and nearly twice as many people are at high risk of developing it. The bit that really stunned me? Diabetes costs the health service roughly 10% of its entire budget. In north America, one in five men over 50 have diabetes. In some parts of the world, it's said as much as a quarter of the population have diabetes or even a third (Nauru)! Type 2 diabetes is six times more common in people of South Asian descent, and three times in people of African and African-Caribbean origin.
Why am I talking about diabetes in a blog dedicated to memory and learning? Because diabetes, if left untreated, has a number of complications, several of which impinge on brain function.

For example, over half of those with type 2 diabetes will die of cardiovascular disease, and vascular risk factors not only increase your chances of heart problems and stroke (diabetes doubles your risk of stroke), but also of cognitive impairment and dementia. Type 2 diabetes is associated with obesity, which can bring about high blood pressure and sleep apnea, both of which are cognitive risk factors.
Both diabetes and hypertension increases the chances of white-matter lesions in the brain (this was even evident in obese adolescents with diabetes), and the degree of white-matter lesions in the brain is related to the severity of age-related cognitive decline and increased risk of Alzheimer's.
Mild cognitive impairment is more likely to develop into Alzheimer's if vascular risk factors such as high blood pressure, diabetes, cerebrovascular disease and high cholesterol are present, especially if untreated. Indeed it has been suggested that Alzheimer's memory loss could be due to a third form of diabetes. And Down syndrome, Alzheimer's, diabetes, and cardiovascular disease, have been shown to share a common disease mechanism.
So diabetes is part of a suite of factors that act on the heart and the brain.
But treatment of such risk factors (e.g. by using high blood pressure medicines, insulin, cholesterol-lowering drugs and diet control, giving up smoking or drinking) significantly reduces the risk of developing Alzheimer's. Bariatric surgery has been found to improve cognition in obese patients. And several factors have been shown to make a significant difference as to whether a diabetic develops cognitive problems.
Older diabetics are more likely to develop cognitive problems if they:
have higher (though still normal) blood pressure,

have gait and balance problems,

report themselves to be in bad health regardless of actual problems (this may be related to stress and anxiety),

have higher levels of the stress hormone cortisol,

don’t manage their condition (poor glucose control),

have depression,

eat high-fat meals.

Glucose control / insulin sensitivity may be a crucial factor even for non-diabetics. A study involving non-diabetic middle-aged and elderly people found that those with impaired glucose tolerance (a pre-diabetic condition) had a smaller hippocampus and scored worse on tests for recent memory. And some evidence suggests that a link found between midlife obesity and increased risk of cognitive impairment and dementia in old age may have to do with poorer insulin sensitivity.

Exercise and dietary changes are of course the main lifestyle factors that can turn such glucose impairment around, and do wonders for diabetes too. In fact, a recent small study found that an extreme low-calorie diet (don’t try this without medical help!) normalized pre-breakfast blood sugar levels and pancreas activity within a week, and may even have permanently cured some diabetics after a couple of months.

Diabetes appears to affect two cognitive domains in particular: executive functioning and speed of processing.

29-Tips for better sleep

aving trouble sleeping is perfectly normal, especially as we age. It’s estimated that half of those older than 55 have trouble getting to sleep or staying asleep.

What to do if your sleep is poor

Let’s start with the easiest situation: you’re not getting enough sleep because you wilfully go to bed too late to achieve your needs.

This is unfortunately all too common. All I can do is point out how desperately important it is to get the sleep you need. By chronically depriving yourself of sleep, you not only are ensuring that your mental powers are under-par, but you have added significantly to the likelihood that you will develop cognitive problems in old age.

Life is a matter of priorities. To change this situation, you need to give sleep a higher priority than you’ve been doing.

Chances are, though, that your sleep deprivation is not wilful, but is caused by problems in getting to sleep, or staying asleep. If this is the case, you are probably aware of the standard advice, but let me bullet-point it first, before getting to less common solutions.

Have a routine

Have a regular schedule

Get some exercise during the day

Don’t do anything too stimulating before going too bed - this includes eating, drinking (caffeine or alcohol), smoking, working, playing games

Make sure your room is quiet and dark (wear earplugs and/or a sleep mask, if you can’t do anything about the environment).

Alcohol and sleep

This needs a special mention, because many people see a ‘nightcap’ as an aid to sleep. It’s true that alcohol can shorten the time it takes to fall asleep. It also increases deep sleep in the first half of the night. However, sleep is more disrupted in the second half. While increased deep sleep is generally good, there are two down-sides here: first, it’s paired with sleep disruption in the second half of the night; second, those predisposed

to problems such as sleep apnea may be more vulnerable to them. Additionally, at high doses of alcohol, REM sleep is significantly reduced, and in any dose, the first REM period is significantly delayed, producing less restful sleep.

All in all, then, while alcohol may give the illusion of improving sleep, it is not in fact doing so.

Stress & anxiety

Stress and anxiety are of course major factors in chronic sleep problems, and the reason would seem to be the thoughts that plague you.

A good strategy for dealing with this is to write all your worries down, preferably with a planned action. Your planned action doesn't have to be a solution! It simply needs to be a first step. Write it down, give it a priority rating or action date.

If your worry is completely fruitless, with no viable action that you can (or want to) take, it's still worth writing it down, along with its possible consequences. You probably don't want to think about those consequences, but this is part of why the worry is plaguing you so much. Write down the possible consequences, and their likelihood, and you will get rid of much of their power over you.

Unfortunately, it seems that worriers are not simply more likely to have sleep problems, but they are more affected by them.

A study in which 18 young adults viewed images that were either disturbing or neutral, which were cued by a red minus sign (something horrible coming up!), a yellow circle (don't worry, nothing disturbing), or a white question mark (you'll have to wait and see), found that activity in the brain's emotional centers, the amygdala and insula, rose dramatically when the participant was sleep deprived, with this effect being most extreme when the participant was an anxious type of person.

Sleep deprivation, it appears, has an effect on emotion that is similar to what is seen in anxiety disorders, and those who are naturally anxious are more vulnerable to these effects.

This means that sleep therapy is even more important for the naturally anxious.

How to relax

If you're prone to stress or anxiety, you're probably familiar with relaxation techniques. They're a great idea, but if you haven't found them as effective as you'd like, the problem may like in the 'mental churn' you can't get rid of. Try the writing strategy first, then follow it up with a relaxation strategy.

If you've been unsuccessfully trying a standard relaxation exercise, you may also find a more mentally challenging relaxation strategy works better for you. T'ai chi, for example, is a form of physical meditation that demands your attention, and thus leaves less room for you to fret about your worries. It's well worth learning for that alone (although it also has physical and mental benefits).

Another less common strategy for dealing with sleep problems is rocking. It does require some expense and effort, given that you need a bed that rocks gently, but it may be worth considering if you're desperate.

The evidence for this is a little sketchy, unfortunately, but it seems a nice idea, and it certainly seems plausible. A small study involving 12 youngish healthy men found that when they took a 45-minute afternoon nap on a bed that rocked slowly, they went to sleep faster, moved into deep sleep faster, and showed more slow brainwaves and sleep spindles, compared to a similar nap on the same bed, held still. It is a very small sample, and a restricted one, which doesn't include anyone with sleep problems. But it's worth noting because apparently every one of the participants showed these effects.

Quiet time

One of the big problems for insomniacs is that typically the more you worry about not being able to get to sleep, the harder it is to fall asleep. Here's a suggestion: redefine your goal. Why do we need sleep? Because without it we feel lousy the next day; we're weaker, and we're less able to think or remember. This is your real goal: giving your mind and body the opportunity to refresh itself.

You need to process the day's material, to discard what you don't need, to file what you do need, to wipe the sheet clean so you can start again. Try focusing on that instead.

Lie quietly in your bed. Make sure that it's quiet and dark. If you find it helpful, you can have gentle music, but not anything that is loud or in any way exciting. Traffic noise, bright light, and temperature extremes, are all common causes of what is termed "environmental sleep disorder". Moreover, one study found that morning performance on a psychomotor vigilance task was significantly worse if the person had been exposed to traffic noise during the night. Light interferes with circadian rhythms, which are also important for learning and memory.

So, lie there quietly in the dark, and guide your mind through the events of the day. When you come to events of particular interest, focus on them, picking out the details that are important to you. Give the event/information a descriptive label. Pay little attention to events that aren't worth remembering (you could try mentally dumping them in a trashcan or dumpster). When you've run through everything, go back to your labeled sets. (My Memory Journal provides a place and structure for you to do all this.)

IMPORTANT! This is NOT about dwelling on things you need to do! Those should all be in your written list. They're done.

This is about processing the day's events and wiping the slate clean for tomorrow.

Let me say again: Bedtime is not, ever, for thoughts of the future.

Nor is it for dwelling on the past, in the sense of emotional wallowing or fretting. What you are doing is housekeeping. You are discarding, filing, and wiping the desk clean.

When you've done that, now is your time for your relaxation exercise. Fill your mind with your meditational image; progressively relax your muscles. Whether or not you fall asleep, your aim is to provide the quiet place your mind needs in order to get on with the processing at an unconscious level. You've done your bit, giving it the best possible start. Now let it do its job.

Providing a quiet place for your mind to process new information is also an excellent strategy during the day, and this is particularly true for those whose sleep is less than optimal. If you're learning a new skill or wanting to remember new information, giving yourself 10-15 minutes of quiet reflection (optimally in a darkened environment) helps consolidate it.

If you're prone to stress-related sleep disturbance, you may also find this strategy useful after any emotionally stressful event.

Sleep and health

It's a truism that sleep gets worse with age, but a recent study suggests that age may not be the main culprit. The main problem is health - which of course also tends to get worse with age. Medications can cause daytime sleepiness; pain and discomfort can interfere with nighttime sleep.

Weight, too, can be a factor in sleep problems. A study of overweight and obese people found that weight loss improved their overall sleep score by about 20%. Interestingly, the loss of belly fat was particularly useful.

Sleep and diet

Sleep length has also been linked to diet. Data from the very large 2007-2008 National Health and Nutrition Examination Survey (NHANES) found that those who slept 5 to

6 hours a night had the largest calorie intake, followed by those who slept the 'standard' 7-8 hours, then those getting less than 5 hours, with those sleeping most (9 hours or more), eating least.
While there were many differences in the make-up of those diets, analysis revealed just a few nutrients that were critically linked to sleep differences. Very short sleep was associated with less intake of tap water, lycopene (found in red- and orange-colored foods, especially tomatoes), and total carbohydrates. Short sleep was associated with less vitamin C, tap water, selenium (found in nuts, meat and shellfish), and more lutein/zeaxanthin (found in green, leafy vegetables). Long sleep was linked to less intake of theobromine (found in chocolate and tea), dodecanoic acid (a saturated fat) choline (found in eggs and fatty meats), total carbohydrates, and more alcohol.
Whether you can change your sleep patterns by changing your diet is as yet unknown, but it is an intriguing speculation.

30-The role of sleep in memory
Why do we need sleep?
A lot of theories have been thrown up over the years as to what we need sleep for (to keep us wandering out of our caves and being eaten by sabertooth tigers, is one of the more entertaining possibilities), but noone has yet been able to point to a specific function of the sleep state that would explain why we have it and why we need so much of it.
One of the things we do know is that young birds and mammals need as much as three times the amount of sleep as adult birds and mammals. It has been suspected that neuronal connections are remodeled during sleep, and this has recently been supported in a study using cats (Cats who were allowed to sleep for six hours after their vision was blocked in one eye for six hours, developed twice as many new or modified brain connections as those cats who were kept awake in a dark room for the six hours after the period of visual deprivation).
Certainly a number of studies have shown that animals and humans deprived of sleep do not perform well on memory tasks, and research has suggested that there may be a relationship between excessive daytime sleepiness (EDS) and cognitive deficits. A recent study has found that for seniors at least, EDS is an important risk factor for cognitive impairment.
The effect of sleep on memory and learning
Some memory tasks are more affected be sleep deprivation than others. A recent study, for example, found that recognition memory for faces was unaffected by people being deprived of sleep for 35 hours. However, while the sleep-deprived people remembered that the faces were familiar, they did have much more difficulty remembering in which of two sets of photos the faces had appeared. In other words, their memory for the context of the faces was significantly worse. (The selective effect of sleep on contextual memory is also supported in a recent mouse study – see below)
While large doses of caffeine reduced the feelings of sleepiness and improved the ability of the sleep-deprived subjects to remember which set the face had appeared in, the level of recall was still significantly below the level of the non-sleep-deprived subjects. (For you coffee addicts, no, the caffeine didn't help the people who were not sleep-deprived).
Interestingly, sleep deprivation increased the subjects' belief that they were right, especially when they were wrong. In this case, whether or not they had had caffeine made no difference.

In another series of experiments, the brains of sleep-deprived and rested participants were scanned while the participants performed complex cognitive tasks. In the first experiment, the task was an arithmetic task involving working memory. Sleep-deprived participants performed worse on this task, and the fMRI scan confirmed less activity in the prefrontal cortex for these participants. In the second experiment, the task involved verbal learning. Again, those sleep-deprived performed worse, but in this case, only a little, and the prefrontal areas of the brain remained active, while parietal lobe activity actually increased. However, activity in the left temporal lobe (a language-processing area) decreased. In the third study, participants were given a "divided-attention" task, in which they completed both an arithmetic and a verbal-learning task. Again, sleep-deprived participants showed poorer performance, depressed brain activation in the left temporal region and heightened activation in prefrontal and parietal regions. There was also increased activation in areas of the brain that are involved in sustained attention and error monitoring.

These results indicate that sleep deprivation affects different cognitive tasks in different ways, and also that parts of the brain are able to at least partially compensate for the effects of sleep deprivation.

Sleep deprivation mimics aging?

A report in the medical journal The Lancet, said that cutting back from the standard eight down to four hours of sleep each night produced striking changes in glucose tolerance and endocrine function that mimicked many of the hallmarks of aging. Dr Eve Van Cauter, professor of medicine at the University of Chicago and director of the study, said, "We suspect that chronic sleep loss may not only hasten the onset but could also increase the severity of age-related ailments such as diabetes, hypertension, obesity and memory loss."

Should we draw any conclusion from the finding that sleep deprivation increased the subjects' belief that they were right, especially when they were wrong, and the finding that chronic sleep deprivation may mimic the hallmarks of aging? No, let us merely note that many people become more certain of their own opinions as they mature into wisdom.

Is sleep necessary to consolidate memories?

This is the big question, still being argued by the researchers. The weight of the evidence, however, seems to be coming down on the answer, yes, sleep is necessary to consolidate memories — although maybe for only some types of memory. Most of the research favoring sleep's importance in consolidation has used procedural / skill memory — sequences of actions.

From this research, it does seem that it is the act of sleep itself, not simply the passage of time, that is critical to convert new memories into long-term memory codes.

Some of the debate in this area concerns the stage of sleep that may be necessary. The contenders are the deep "slow wave" sleep that occurs in the first half of the night, and "REM" (rapid eye movement) sleep (that occurs while you are dreaming). Experiments that have found sleep necessary for consolidation tend to support slow-wave sleep as the important part of the cycle, however REM sleep may be important for other types of memory processing.

Sleep studies cast light on the memory cycle

Two new studies provide support both for the theory that sleep is important for the consolidation of procedural memories, and the new theory of what I have termed the "memory life-cycle".

In the first study, 100 young adults (18 to 27) learned several different finger-tapping sequences. It was found that participants remembered the sequence even if they

learned a second sequence 6 hours later, and performance on both sequences improved slightly after a night's sleep. However, if, on day 2, people who had learned one sequence were briefly retested on it and then trained on a new sequence, their performance on the first sequence plummeted on day 3. If the first sequence wasn't retested before learning the new sequence, they performed both sequences accurately on day 3.
In another study, 84 college students were trained to identify a series of similar-sounding words produced by a synthetic-speech machine. Participants who underwent training in the morning performed well in subsequent tests that morning, but tests later in the day showed that their word-recognition skill had declined. However, after a full night's sleep, they performed at their original levels. Participants trained in the evening performed just as well 24 hours later as people trained in the morning did. Since they went to bed shortly after training, those in the evening group didn't exhibit the temporary performance declines observed in the morning group.
On the basis of these studies, researchers identified three stages of memory processing: the first stage of memory — its stabilization — seems to take around six hours. During this period, the memory appears particularly vulnerable to being "lost". The second stage of memory processing — consolidation — occurs during sleep. The third and final stage is the recall phase, when the memory is once again ready to be accessed and re-edited. (see my article on consolidation for more explanation of the processes of consolidation and re-consolidation)
The researchers made a useful analogy with creating a word-processing document on the computer. The first stage is when you hit "Save" and the computer files the document in your hard drive. On the computer, this takes seconds. The second stage is comparable to someone coming and tidying up your word document — reorganizing it and tightening it up.
The most surprising aspect of this research is the time it appears to take for memories to initially stabilize — seconds for the computer saving the document, but up to six hours for us!

31-Understanding scientific text
In the last part I talked about retrieval structures and their role in understanding what you're reading. As promised, this month I'm going to focus on understanding scientific text in particular, and how it differs from narrative text.

First of all, a reminder about situation models. A situation, or mental, model is a retrieval structure you construct from a text, integrating the information in the text with your existing knowledge. Your understanding of a text depends on its coherence; it's generally agreed that for a text to be coherent it must be possible for a single situation model to be constructed from it (which is not to say a text that is coherent is necessarily coherent for you —that will depend on whether or not you can construct a single mental model from it).
There are important differences in the situation models constructed for narrative and expository text. A situation model for a narrative is likely to refer to the characters in it and their emotional states, the setting, the action and sequence of events. A situation model for a scientific text, on the other hand, is likely to concentrate on the components of a system and their relationships, the events and processes that occur during the working of the system, and the uses of the system.
Moreover, scientific discourse is rooted in an understanding of cause-and-effect that differs from our everyday understanding. Our everyday understanding, which is

reflected in narrative text, sees cause-and-effect in terms of goal structures. This is indeed the root of our superstitious behavior — we (not necessarily consciously) attribute purposefulness to almost everything! But this approach is something we have to learn not to apply to scientific problems (and it requires a lot of learning!).

This is worth emphasizing: science texts assume a different way of explaining events from the way we are accustomed to use — a way that must be learned.

In general, then, narrative text (and 'ordinary' thinking) is associated with goal structures, and scientific text with logical structures. However, it's not quite as clear-cut a distinction as all that. While the physical sciences certainly focus on logical structure, both the biological sciences and technology often use goal structures to frame their discussions. Nevertheless, as a generalization we may say that logical thinking informs experts in these areas, while goal structures are what novices focus on.

This is consistent with another intriguing finding. In a comparison of two types of text —ones discussing human technology, and ones discussing forces of nature — it was found that technological texts were more easily processed and remembered. Indications were that different situation models were constructed — a goal-oriented representation for the technological text, and a causal chain representation for the force of nature text. The evidence also suggested that people found it much easier to make inferences (whether about agents or objects) when human agents were involved. Having objects as the grammatical subject was clearly more difficult to process.

Construction of the situation model is thus not solely determined by comprehension difficulty (which was the same for both types of text), but is also affected by genre and surface characteristics of the text.

There are several reasons why goal-oriented, human-focused discourse might be more easily processed (understood; remembered) than texts describing inanimate objects linked in a cause-effect chain, and they come down to the degree of similarity to narrative. As a rule of thumb, we may say that to the degree that scientific text resembles a story, the more easily it will be processed.

Whether that is solely a function of familiarity, or reflects something deeper, is still a matter of debate.

Inference making is crucial to comprehension and the construction of a situation, because a text never explains every single word and detail, every logical or causal connection. In the same way that narrative and expository text have different situation models, they also involve a different pattern of inference making. For example, narratives involve a lot of predictive inferences; expository texts typically involve a lot of backward inferences. The number of inferences required may also vary.

One study found that readers made nine times as many inferences in stories as they did in expository texts. This may be because there are more inferences required in narratives — narratives involve the richly complex world of human beings, as opposed to some rigidly specified aspect of it, described according to a strict protocol. But it may also reflect the fact that readers don't make all (or indeed, anywhere near) the inferences needed in expository text. And indeed, the evidence indicates that students are poor at noticing coherence gaps (which require inferences).

In particular, readers frequently don't notice that something they're reading is inconsistent with something they already believe. Moreover, because of the limitations of working memory, only some of the text can be evaluated for coherence at one time (clearly, the greater the expertise in the topic, the more information that can be evaluated at one time — see the previous newsletter's discussion of long-term working

memory). Less skilled (and younger) readers in particular have trouble noticing inconsistencies within the text if they're not very close to each other.
Let's return for a moment to this idea of coherence gaps. Such gaps, it's been theorized, stimulate readers to seek out the necessary connections and inferences. But clearly there's a particular level that is effective for readers, if they often miss them. This relates to a counter-intuitive finding — that it's not necessarily always good for the reader if the text is highly coherent. It appears that when the student has high knowledge, and when the task involves deep comprehension, then low coherence is actually better. It seems likely that knowledgeable students reading a highly coherent text will have an "illusion of competence" that keeps them from processing the text properly. This implies that there will be an optimal level of coherence gaps in a text, and this will vary depending on the skills and knowledge base of the reader.
Moreover, the comprehension strategy generally used with simple narratives focuses on referential and causal coherence, but lengthy scientific texts are likely to demand more elaborate strategies. Such strategies are often a problem for novices because they require more knowledge than can be contained in their working memory. Making notes (perhaps in the form of a concept map) while reading can help with this.
Next month I'll continue this discussion, with more about the difficulties novices have with scientific texts and what they or their teachers can do about it, and the problems with introductory textbooks. In the meantime, the take-home message from this is:
Understanding scientific text is a skill that must be learned;
Scientific text is easier to understand the more closely it resembles narrative text, with a focus on goals and human agents;
How well the text is understood depends on the amount and extent of the coherence gaps in the text relative to the skills and domain knowledge of the reader.

32-Reading Scientific Text
There are many memory strategies that can be effective in improving your recall of text. However, recent research shows that it is simplistic to think that you can improve your remembering by applying any of these strategies to any text. Different strategies are effective with different types of text.
One basic classification of text structure would distinguish between narrative text and expository text. We are all familiar with narrative text (story-telling), and are skilled in using this type of structure. Perhaps for this reason, narrative text tends to be much easier for us to understand and remember. Most study texts, however, are expository texts.
Unfortunately, many students (perhaps most) tend to be blind to the more subtle distinctions between different types of expository structure, and tend to treat all expository text as a list of facts. Building an effective mental model of the text (and thus improving your understanding and recall) is easier, however, if you understand the type of structure you're dealing with, and what strategy is best suited to deal with it.
Identifying structure
Five common types of structure used in scientific texts are:
Generalization: the extension or clarification of main ideas through explanations or examples
Enumeration: listing of facts
Sequence: a connecting series of events or steps
Classification: grouping items into classes

Comparison / contrast: examining the relationships between two or more things

Let's look at these in a little more detail.

Generalization

In generalization, a paragraph always has a main idea. Other sentences in the paragraph either clarify the main idea by giving examples or illustrations, or extend the main idea by explaining it in more detail. Here's an example:

Irritability is defined as an organism's capacity to respond to conditions outside itself. ... The organism's response is the way it reacts to stimulus. For example, a plant may have a growth response. This happens when ...

Enumeration

Enumeration passages may be a bulleted or numbered list, or a list of items in paragraph form, for example:

There are four general properties of solids. Tenacity is a measure of ... Hardness is ... Malleability refers to ... Ductility is ...

Sequence

A sequence describes a series of steps in a process. For example:

Hearing can be described in five separate stages. First, ...

Classification

In classification, items are grouped into categories. For example:

Experimental variables can be grouped into one of two categories, either a manipulated variable or a controlled variable. A variable that can ...

Comparison / contrast

This type of text looks at relationships between items. In comparison, both similarities and differences are studied. In contrast, only the differences are noted. For example:

There are two different hypotheses for the origin of the earth: the nebular hypothesis and the comet-produced hypothesis. The nebular hypothesis maintains ... In contrast, the comet-produced hypothesis states ... The first hypothesis assumes ... The latter hypothesis asserts ...

[examples taken from Cook & Mayer 1988]

A study [1] involving undergraduate students inexperienced in reading science texts (although skilled readers otherwise) found that even a small amount of training substantially improved the students' ability to classify the type of structure and use it appropriately.

Let's look briefly at the training procedures used:

Training for generalization

This involved the following steps:

- identify the main idea
- list and define the key words
- restate the main idea in your own words
- look for evidence to support the main idea
  - what kind of support is there for the main idea?
  - are there examples, illustrations?
  - do they extend or clarify the main idea?

Training for enumeration

This involved the following steps:

- name the topic
- identify the subtopics
- organize and list the details within each subtopic, in your own words

Training for sequence

This involved the following steps:

identify the topic
name each step and outline the details within each
briefly discuss what's different from one step to another

[Only these three structures were covered in training]

Most effective text structures

Obviously, the type of structure is constrained by the material covered. We can, however, make the general statement that text that encourages the student to make connections is most helpful in terms of both understanding and memory.

In light of this, compare/contrast would seem to be the most helpful type of text. Another text structure that is clearly of a similar type has also been found to be particularly effective: refutational text. In a refutational text, a common misconception is directly addressed (and refuted). Obviously, this is only effective when there is a common misconception that stands in the way of the reader's understanding -- but it's surprising how often this is the case! Incompatible knowledge is at least as bad as a lack of knowledge in hindering the learning of new information, and it really does need to be directly addressed.

Refutational text is however, not usually enough on its own. While helpful, it is more effective if combined with other, supportive, strategies. One such strategy is elaborative interrogation, which involves (basically) the student asking herself why such a fact is true.

Unfortunately, however, text structures that encourage connection building are not the most common type of structure in scientific texts. Indeed, it has been argued that "the presentation of information in science textbooks is more likely to resemble that of a series of facts [and thus] presents an additional challenge that may thwart readers' efforts to organize text ideas relative to each other".

Most effective strategies

The fundamental rule (that memory and understanding are facilitated by any making of connections) also points to the strategies that are most effective.

As a general rule, strategies that involve elaborating the connections between concepts in a text are the most effective, but it is also true that the specifics of such strategies vary according to the text structure (and other variables, such as the level of difficulty). Let's look at how such a linking strategy might be expressed in the context of our five structures.

Generalization

Restatement in your own words -- paraphrasing -- is a useful strategy not simply because it requires you to actively engage with the material, but also because it encourages you to connect the information to be learned with the information you already have in your head. We can, however, take this further in the last stage, when we look for the evidence supporting the main idea, if we don't simply restrict ourselves to the material before us, but actively search our minds for our own supporting evidence.

Enumeration

This text structure is probably the hardest to engage with. You may be able to find a connective thread running through the listed items, or be able to group the listed items in some manner, but this structure is the one most likely to require mnemonic assistance (see verbal mnemonics and list-learning mnemonics).

Sequence

With this text structure, items are listed, but there is a connecting thread — a very powerful one. Causal connections are ones we are particularly disposed to pay

attention to and remember; they are the backbone of narrative text. So, sequence has a strong factor going for it.
Illustrations particularly lend themselves to this type of structure, and research has shown that memory and comprehension is greatly helped when pictures portraying a series of steps, in a cause-and-effect chain, are closely integrated with explanatory text. The closeness is vital — a study that used computerized instruction found dramatic improvement in memory when the narration was synchronous with the animation, for example, but there was no improvement when the narration was presented either before or after the text. If you are presented with an illustration that is provided with companion text, but is not closely integrated with it, you will probably find it helpful to integrate it with the text yourself.
Classification
Classification is frequently as simple as grouping items. However, while this is in itself a useful strategy that helps memory, it will be more effective if the connections between and within groups are strong and clear. Connections within groups generally emphasize similarities, while connections between groups emphasize both similarities (between closely connected groups) and differences. Ordering groups in a hierarchical system is probably the type of arrangement most familiar to students, but don't restrict yourself to it. Remember, the important thing is that the arrangement has meaning for you, and that the connections emphasize the similarities and differences.
Compare / contrast
This type of structure lends itself, of course, to making connections. Your main strategy is probably therefore to simply organize the material in such a way as to make those connections clear and explicit.

33-Context & the conditionalization of knowledge
Context is absolutely critical to successful communication. Think of the common experience of being a stranger at a family gathering or a meeting of close friends. Even familiar words and phrases may take on a different or additional meaning, among people who have a shared history. Many jokes and comments will be completely unintelligible, though you all speak the same language.

American anthropologist Edward Hall makes a useful distinction between ‘High context’ and ‘Low context’ communications. Your family gathering would be an example of a high context situation. In this setting, much of the meaning is carried in the speakers, their relationships, their knowledge of each other. In a low context situation, on the other hand, most of the meaning is carried in the actual words.
Part of the problem with email, as we all recognize, is that the context is so lacking, and the burden lies so heavily on the words themselves.
The importance of context for comprehension has, of course, profound implications for learning and memory.
I was reminded of this just the other day. I’m a fan of a TV program called NCIS. I only discovered it, however, at the beginning of the third season. After I’d watched it for some weeks, I purchased the DVDs of the earlier seasons. Most recently, I bought the DVD of season 3, which I had, of course, seen on TV. Watching the first episode of that season, which was the first episode of NCIS I ever saw, I was surprised to hear a line which I had no memory of, that was freighted with significance and led me to a much deeper understanding of the relationship between two of the characters — but which had meant absolutely nothing to me when I originally saw it, ignorant as I was of any of the characters and the back story.

The revelation meant nothing to me as a novice to the program, and so I didn't remember it, but it meant everything to me as (dare I say it?) an expert.

Context is such a slippery word; so hard to define and pin down. But I think it's fair to say that the difference between the novice and the expert rests on this concept. When an expert is confronted with a piece of information from her area of expertise, she knows what it means and where it belongs — even if the information is new to her. Because of this, she can acquire new information much more easily than a novice. But this advantage applies only in the expert's area of expertise.

To take another example from the frivolous world of popular culture, a British study of fans of the long-running radio soap opera The Archers were given one of two imaginary scripts to read. One story was representative of the normal events in The Archers (a visit to a livestock market); the other was atypical (a visit to a boat show). These experts were able to remember many more details of the typical, market story than a group of subjects who knew little about the soap opera, but were no better at remembering details for the atypical story. Most importantly, this occurred even though the two stories shared many parallel features and most of the questions (and answers) used to assess their memory were the same. This indicates the specificity of expert knowledge.

Part of the advantage experts have is thought to rest on the 'conditionalization' of knowledge. That is, experts' knowledge includes a specification of the contexts in which it is relevant.

It is surprising to many, this idea that it is not necessarily a lack of knowledge that is the problem — that people often have relevant knowledge and don't apply it. In reading, for example, readers often don't make inferences that they are perfectly capable of making, on the knowledge they have, unless the inferences are absolutely demanded to make sense of the text.

Another example comes from the making of analogies. I discuss this in my workbook on taking notes. Here's a brief extract:

Rutherford's comparison of the atom to the solar system gave us a means to understand the atom. The story goes that Newton 'discovered' gravity when an apple fell on his head — because of the comparison he made, realizing that the motion of an apple falling from a tree was in some sense like the motion of the planets. These are comparisons called analogies, and analogy has been shown to be a powerful tool for learning.

But the problem with analogies is that we have trouble coming up with them.

Generally, when we make analogies, we use an example we know well to help us understand something we don't understand very well. This means that we need to retrieve from memory an appropriate example. But this is clearly a difficult task; people frequently fail to make appropriate connections — even, surprisingly, when an appropriate connection has recently come their way. In a study where people were given a problem to solve after reading a story in which an analogous problem was solved, 80% didn't think of using the story to solve the problem until the analogy was pointed out to them.

It's thought that retrieving an appropriate analogy is so difficult because of the way we file information in memory. Certainly similarity is an important attribute in our filed memories, but it's not the same sort of similarity that governs analogies. The similarity that helps us retrieve memories is a surface similarity — a similarity of features and context. But analogies run on a deeper similarity — a similarity of structure, of relations between objects. This will only be encoded if you have multiple examples (at least more than one) and make an explicit effort to note such relations.

The conditionalization of knowledge is of course related to the problem of transfer. Transfer refers to the ability to extend (transfer) learning from one situation to another (read more about it here) . Transfer is frequently used as a measure of successful learning. It's all very well to know that 399-(399*0.1) = 359.1, but how far can you be said to understand it — how much use is it — if you can't work out how much a $3.99 item will cost you if you have a 10% discount? (In fact, the asymmetry generally works the other way: many people are skilled at working out such purchase calculations, but fall apart when the problem is transferred to a purely numerical problem).
Transfer is affected by the context in which the information was originally acquired — obviously transfer is particularly problematic if you learn the material in a single context — and this is partly where the experts achieve their conditionalization: because, spending so much time with their subject they are more likely to come across the same information in a variety of contexts. But the more important source is probably the level of abstraction at which experts can operate (see my article on transfer for examples of how transfer is facilitated if the information is framed at a higher level of abstraction).
In those with existing expertise, an abstract framework is already in place. When an expert is confronted by new information, they automatically try and fit it into their existing framework. Whether it is consistent or inconsistent with what is already known doesn't really matter — either way it will be more memorable than information that makes no deep or important connections to familiar material.
Let's return to this idea of high and low context. Hall was talking about communications, in the context of different cultures (interestingly, he found cultures varied in the degree to which they were context-bound), but the basic concept is a useful one in other contexts. It is helpful to consider, when approaching a topic, either as student or teacher, the degree to which understanding requires implicit knowledge. A high context topic might be thought of as one that assumes a lot of prior knowledge, that assumes a knowledge of deeper structure, that is difficult to explain in words alone. A low context topic might be thought of as one that can be clearly and simply expressed, that can largely stand alone. Learning the basics of a language — how to conjugate a verb; some simple words and phrases — might be thought of as a low context topic, although clearly mastery of a language requires the complex and diverse building up of experiences that signifies a high context topic (and also clearly, some languages will be more 'high context' than others).
There is nothing particularly profound about this distinction, but an awareness of the 'contextual degree' of a topic or situation, is helpful for students, teachers, and anyone involved in trying to communicate with another human being (or indeed, computer!). It's also helpful to be aware that high context situations require much more expertise than low context ones.

34-Retrieval practice & the keyword mnemonic

Retrieval practice, as its name suggests, is a simple strategy that involves retrieving the target information one or more times prior to testing. It is not the same as repetition or rehearsal! The idea is not to simply repeat the correct information, but to try and retrieve it. Feedback as to the correct answer may or may not follow.
The keyword mnemonic is the most studied mnemonic strategy, and of proven effectiveness in learning vocabulary, most particularly when measured against rote repetition or "use your own methods", but also when compared with the popular context method (students experience the word to be learned in several different meaningful contexts; they may or may not have to guess the meaning from the

context). It has also effectively been used to learn artists' styles, taxonomic information, attribute information, and the main points in text passages.
Results from using the keyword method have been quite dramatic. For example, in a classic study from the researchers that developed this strategy (Atkinson & Raugh 1975), over a third of the 120 words were remembered more than 80% of the time in the keyword condition, compared to only one item in the control condition (glaz for eye — a mnemonic link so obvious I am sure most of the control participants used it). Moreover, only seven words were remembered less than half the time in the keyword condition, compared to 70 in the control ("use your own method") condition! Overall, the keyword group recalled 72% of the words when they were tested on the day following the three study days (40 words were studied each day), compared to 46% by the control group. When they were (without warning) tested again six weeks later, the keyword group remembered 43% compared to the control group's 28%.
As you see, the benefits of the method are quite clear.
Which demonstrates how impressive it is that in a study that compared the two, retrieval practice resulted in the same, and in some cases, better performance than the keyword method.
In this 2007 study1, two lab experiments involving university students compared the learning of German words using either the keyword mnemonic, retrieval practice, or rote repetition, and found no difference in performance between the two experimental groups, and both significantly better than rote repetition. This was followed by an experiment involving 56 secondary school pupils, comparing the learning of German words learned in four different ways (that is, all the pupils were given the same instruction; groups of words were presented in different ways).
In the first section of the instruction booklet, each English word with its German translation was presented with an elaborating sentence (for example, "The German for SHARP is SCHARF, scharf also means hot (as in spicy)."; "The German for LIGHTHOUSE is LEUCHTTURM, Leuchtturm consists of the two words for shine and tower.") — this was the elaboration strategy. In the next section (retrieval practice), the English and German words were read out when first presented, and on the following pages the students were required to retrieve the German word on seeing the English word. There were filler pages in between each retrieval attempt on the expanding schedule of 1-3-5-7 (that is, one intervening filler item before the first attempt, three items before the second attempt, and so on). In the third, keyword, section, the English and German words were presented with a description of a suggested image (e.g., "The German for SHARP is SCHARF. Imagine cutting a German flag with SHARP scissors." "The German for LIGHTHOUSE is LEUCHTTURM. Imagine people LOITERING near a lighthouse."). In the last section, a strategy combining both the keyword and retrieval practice was employed.
The time allowed for each page was controlled, and was only a few seconds.
There were two tests: recalling the English meaning on seeing the German words, and giving the German words when presented with the English meaning. The tests were given twice — immediately, and one week later. For the easier task (giving the English in response to the German), words learned using the elaboration strategy were significantly more poorly remembered, and results from the other three strategies were not significantly different in the immediate test, but after a week, the words learned by the combined method were significantly better remembered than those learned by the others. Words learned by the retrieval practice strategy were slightly, but not quite significantly, better remembered than those learned by the keyword method.

For the harder task (remembering the German), the difference between retrieval practice and keyword mnemonic reached statistical significance.
The big advantage of retrieval practice is of course that it is a very simple, easily learned technique. It also requires much less cognitive effort than the keyword mnemonic, which puts off many people because of the difficulty of finding good keywords, and the effort (which is greater for some than for others) of creating images.
There are two aspects of the retrieval practice strategy, as it was used here, that should be noted. One is the basic principle that retrieval is always better than rehearsal, because retrieval is the task you should be practicing for, and because rehearsal gives you no feedback as to how well you have learned, and retrieval does. That is why testing is so valuable — more valuable as a learning tool than as an assessment tool. Testing teaches; even pretesting (before the student even knows the information to be learned) improves learning. (Two studies on this are reported in a Scientific American article at http://www.scientificamerican.com/article.cfm?id=getting-it-wrong)
The second aspect is that the retrieval occurred on a distributed schedule.
I have talked before about the importance of spacing your learning (rehearsal; practice). So now I'll just add one thing, from a recent (2009) study2.
Interleaving practice is a related strategy that has (mostly in the area of motor skills, but of wider applicability) been shown to improve learning. With interleaved practice, a lesson is followed by practice problems relating to many earlier lessons, ordered so that no consecutive problems are of the same type. As is readily apparent, interleaving naturally involves distributed practice, so it's not clear whether interleaving is on its own, separate from the effects of distribution, of benefit. This new study managed to disentangle interleaving from spacing, and found that, even when spacing was held constant, interleaving more than doubled test scores (77% vs 38%).
However, and this is perhaps the really interesting part, it did so having impaired performance during practice. That is, not unexpectedly, performance was poorer during the learning period, when practice was interleaved.
And here we bring in a concept that is also of relevance in discussing the value of testing for learning: the idea of desirable difficulty (a term devised by Robert Bjork and colleagues).
In these days of trying not damage students' self-esteem by having them experience failure, it is well to remember this concept.

35-Desirable difficulty for effective learning
When we are presented with new information, we try and connect it to information we already hold. This is automatic. Sometimes the information fits in easily; other times the fit is more difficult — perhaps because some of our old information is wrong, or perhaps because we lack some of the knowledge we need to fit them together.
When we're confronted by contradictory information, our first reaction is usually surprise. But if the surprise continues, with the contradictions perhaps increasing, or at any rate becoming no closer to being resolved, then our emotional reaction turns to confusion.
Confusion is very common in the learning process, despite most educators thinking that effective teaching is all about minimizing, if not eliminating, confusion.
But recent research has suggested that confusion is not necessarily a bad thing. Indeed, in some circumstances, it may be desirable.
I see this as an example of the broader notion of 'desirable difficulty', which is the subject of my current post. But let's look first at this recent study on confusion for learning.

In the study, students engaged in ‘trialogues’ involving themselves and two animated agents. The trialogues discussed possible flaws in a scientific study, and the animated agents took the roles of a tutor and a student peer. To get the student thinking about what makes a good scientific study, the agents disagreed with each other on certain points, and the student had to decide who was right. On some occasions, the agents made incorrect or contradictory statements about the study.

In the first experiment, involving 64 students, there were four opportunities for contradictions during the discussion of each research study. Because the overall levels of student confusion were quite low, a second experiment, involving 76 students, used a delayed manipulation, where the animated agents initially agreed with each other but eventually started to express divergent views. In this condition, students were sometimes then given a text to read to help them resolve their confusion. It was thought that, given their confusion, students would read the text with particular attention, and so improve their learning.

In both experiments, on those trials which genuinely confused the students, those students who were initially confused by the contradiction between the two agents did significantly better on the test at the end.

A side-note: self-reports of confusion were not very sensitive, and students’ responses to forced-choice questions following the contradictions were more sensitive at inferring confusion. This is a reminder that students are not necessarily good judges of their own confusion!

The idea behind all this is that, when there’s a mismatch between new information and prior knowledge, we have to explore the contradictions more deeply — make an effort to explain the contradictions. Such deeper processing should result in more durable and accessible memory codes.

Such a mismatch can occur in many, quite diverse contexts — not simply in the study situation. For example, unexpected feedback, anomalous events, obstacles to goals, or interruptions of familiar action sequences, all create some sort of mismatch between incoming information and prior knowledge.

However, all instances of confusion aren’t necessarily useful for learning and memory. They need to be relevant to the activity, and of course the individual needs to have the means to resolve the confusion.

As I said, I see a relationship between this idea of the right level and type of confusion enhancing learning, and the idea of desirable difficulty. I’ve talked before about the ‘desirable difficulty’ effect (see, for example, Using 'hard to read' fonts may help you remember more). Both of these ideas, of course, connect to a much older and more fundamental idea: that of levels of processing. The idea that we can process information at varying levels, and that deeper levels of processing improve memory and learning, dates back to a paper written in 1972 by Craik and Lockhart (although it has been developed and modified over the years), and underpins (usually implicitly) much educational thinking.

But it’s not so much this fundamental notion that deeper processing helps memory and learning, and certain desirable difficulties encourage deeper processing, that interests me as much as idea of getting the level right.

Too much confusion is usually counter-productive; too much difficulty the same.

Getting the difficulty level right is something I have talked about in connection with flow. On the face of it, confusion would seem to be counterproductive for achieving flow, and yet ... it rather depends on the level of confusion, don't you think? If the student has clear paths to follow to resolve the confusion, the information flow doesn't need to stop.

This idea also, perhaps, has connections to effective practice principles — specifically, what I call the ‘Just-in-time rule’. This is the principle that the optimal spacing for your retrieval practice depends on you retrieving the information just before you would have forgotten it. (That’s not as occult as it sounds! But I’m not here to discuss that today.)

It seems to me that another way of thinking about this is that you want to find that moment when retrieval of that information is at the ‘right’ level of difficulty — neither too easy, nor too hard.

Successful teaching is about shaping the information flow so that the student experiences it — moment by moment — at the right level of difficulty. This is, of course, impossible in a factory-model classroom, but the mechanics of tailoring the information flow to the individual are now made possible by technology.

But technology isn't the answer on its own. To achieve optimal results, it helps if the individual student is aware that the success of their learning depends on (or will at least be more effective — for some will be successful regardless of the inadequacy of the instruction) managing the information flow. Which means they need to provide honest feedback, they need to be able to monitor their learning and recognize when they have ‘got’ something and when they haven’t, and they need to understand that if one approach to a subject isn’t working for them, then they need to try a different one.

Perhaps this provides a different perspective for some of you. I'd love to hear of any thoughts or experiences teachers and students have had that bear on these issues.

36-Flashcards

Flashcards are cards with a word (or phrase) on one side and its translation on the other. You can buy ready-made flashcards, and these can certainly be helpful, particularly if you're inexperienced at learning another language. However, it is more effective if you make them yourself. Not only will the cards be customized to your own use, but the activity of selecting words and writing them down help you learn them.

A standard way of using flashcards is simply to go through a set number each day, separating out those you have trouble with, so you can review them more often. Keep these ones handy so that you can go through them at odd moments during the day when you're waiting for something.

Use the flashcards as a handy way to group words in different ways. Deal out the cards and move them around, looking for connections.

If you have word-family flashcards (recommended) - e.g., cards with various related forms of a word - you can make different sentences with your cards. You could also play cards with them, if you have others to play with. You could play a version of rummy, for example, where the sets are infinitive, present tense, future tense, past perfect. Use your imagination!

A bingo game with flashcards is another fun way to practice. Construct bingo cards (large cards divided into a certain number of spaces the same size as your flashcards) with the native language words on it. While this is better played with others, you can at a pinch play with yourself, simply picking out a flashcard from the pile and seeing how quickly you can match it with its counterpart.

Learning words in isolation will not help you much in dealing with words in context. You do need to practice reading/writing/speaking/listening sentences. But flashcards are a useful means of memorizing vocabulary.

37-Subliminal & sleep learning

Subliminal learning achieved notoriety back in 1957, when James Vicary claimed moviegoers could be induced to buy popcorn and Coca-Cola through the use of messages that flashed on the screen too quickly to be seen. The claim was later shown to be false, but though the idea that people can be brainwashed by the use of such techniques has been disproven (there was quite a bit of hysteria about the notion at the time), that doesn't mean the idea of subliminal learning is crazy.

Ten years ago, researchers demonstrated that subliminal messages do indeed affect human cognition — and showed the limits of that influence [1]. The study demonstrated that, to have an effect on a person's decision, the subliminal message had to be received very very soon before that decision (a tenth of a second or less), and the person had to be forced to make the decision very quickly. Moreover, there was no memory trace detectable, indicating no permanent record was stored in memory.

But even such brief, low-level learning seems to require some level of attention. A study [2] found that subliminal learning doesn't occur if the subliminal stimuli are presented during what has been termed an "attentional blink" You may recall when I've discussed multi-tasking, I've said that we can't do two things at the same time — that tasks have to "queue" for attention. When a bottleneck occurs in the system, this attentional "blink" occurs.

But low-level sensory processing, which is an automatic process, isn't affected by the attentional blink, so the finding that subliminal learning is affected by the blink indicates that subliminal stimuli require some high-level cognitive processing.

This finding has been confirmed by other studies. One such study [3] also has implications for reading. Participants in the study were shown either words or pronounceable nonwords and asked to perform either a lexical task (to identify whether the word they saw was a real word or a nonsense word) or a pronunciation task on the words. Unbeknownst to the participants however, they had been first presented with a subliminal word that either matched or didn't match the target word. People performed the tasks faster when the subliminal word was identical to the target word. However (and this is the interesting bit), the researchers then applied a magnetic pulse (transcranial magnetic stimulation) to the key brain regions of the brain before presenting the subliminal information. By applying TMS to one brain area or the other, they found they could selectively disrupt the subliminal effect for either the lexical or pronunciation task. In other words, it seems that, even when the stimulus is subliminal, the brain takes into account the conscious task instructions. Our expectations shape our processing of subliminal stimuli.

Another study [4] suggests that motivation is important, and also, perhaps, that some stimuli are more suitable than others. The study found that thirsty people could be encouraged to drink more, and also pay more for their drink, after being exposed to subliminal smiling faces. Subliminal frowning faces had the opposite effect. However, how much, and whether, the faces had an effect on drinking, depended on the person's thirst. Those who weren't thirsty weren't affected at all. Smiles and frowns are of course stimuli to which we are very responsive.

So clearly, although it is possible to be unconsciously affected by stimuli that can't be consciously detected, the effect is both small and fleeting. However, that doesn't mean more long-term effects can't be experienced as a result of information we're not conscious of.

Psychologists make a distinction between explicit memory and implicit memory. Explicit memory is what you're using when you remember or recognize something — it's what we tend to think of as "memory". Implicit memory, on the other hand, is a concept that reflects the fact that sometimes people act in ways that are clearly affected

by earlier experiences they have had, even though they are not consciously recalling such experiences.
Another study [5] that used erotic images (because, like smiling and frowning faces, these are particularly potent stimuli, making it easy to see a response) found that when your eyes are presented with erotic images in a way that keeps you from becoming aware of them, your brain can still detect them — evidenced by the way people respond to the images according to their gender and sexual orientation.
The study is more evidence that the brain processes more visual information than we are conscious of — which is an important part in the process of determining what we'll pay attention to. But the researchers believe that the information is probably destroyed at an early stage of processing — in other words, as with subliminal stimuli, there is probably no permanent record of the experience.
Which leads me to sleep learning. This was a big idea when I was young, in the science fiction I read — the idea that you could easily master new languages by being instructed while you were asleep.
Well, the question of whether learning can take place during sleep (and I'm not talking about the consolidation of learning that's occurred earlier) is one that has been looked at in animal studies. It has been shown that simple forms of learning are indeed possible during sleep. However, the way in which associations are formed is clearly altered even for simple learning, and complex forms of learning do not appear to be possible.[6]
As far as humans are concerned, the evidence is that any learning during sleep must occur during the lightest stage of sleep, when you still have some awareness of the world around you, and that what you are learning must be already familiar (presented previously while you were awake and paying attention) and not requiring any understanding.
All the evidence suggests that, although information can be processed without conscious awareness, there are severe limitations on that information. If you want to "know" something in the proper meaning of the word — be able to recall it, think about it — you need to actively engage with the information. No free lunches, I'm afraid!
But that doesn't mean unconscious influences don't have important implications for learning and memory. A paper provided online in the Scientific American Mind Matters blog describes how a single, 15-minute intervention erased almost half the racial achievement gap between African American and white students. And this is entirely consistent with a number of studies showing how our cognitive performance is affected by what we think of ourselves (which is affected by what others think of us).

38-Interested in language
Here's the reason I haven't been updating my website or sending out my newsletter for a long time — I've been working on a dictionary. The Indo-European Cognate Dictionary, to be precise. It's out now, and I'm really excited about it. Excited that it's done, excited than I now have a physical copy that I can use myself, excited because — hey, I've written a dictionary! It weighs in at 545 pages, and it's available in the usual digital formats, except Kindle. If I work out how to get Kindle to display the non-Roman scripts properly, it will appear in that format too, but don't hold your breath. Why Kindle can't do this, when ePub (the format used by practically every other reader) does it no problem, without any special measures needed, escapes me totally, but there it is.

Anyway, what's this odd-sounding dictionary about, you may ask — and what does it have to do memory & learning? Well, if you've done any study of a language related to your own, you'll know about cognates. They're the words that are easiest to learn because they're similar to the words you already know, because they're descended from the same root word. Words like Spanish importante / English important; French authentique / English authentic; German Apfel / English apple; Dutch mixen / English mix; Iceland eyland / English island. How easy a language is to learn is partly down to the number of shared cognates — Spanish, for example, is one of the easiest languages for English speakers to learn, because there's a huge number of words that are very very similar.

But not all cognates are as obvious as the examples I just cited. For example, English ban is related to French fable, to Spanish infando, to German Konfession, to English microphone to Polish bajka to Hindi ???? (bh???) to Dutch bahasa. All of which looks interesting but not particularly helpful, until you contemplate the full set, what I call the cognate cluster:

If you study this cluster, you can start to see the patterns in the way the Proto-Indo-European root word has evolved and spread through its daughter languages. Once you realize that f (ph in Greek) and b are the same letter in a sense (that is, the b sound in the root stayed the same in some daughter languages, but changed to the similar f sound in others), then you can see similarities in the words that you missed before. Once you recognize the regular suffixes and inflections that modify words in Greek and Latin, that are then carried on down in their descendants, then you can see the core of the word, and understand what the modifying bits indicate.

And the reason why I thought this was really useful, is that learning the sheer number of words needed to be fluent, or even useful, in a language, is the bit where most people fall by the wayside. Now, as I've said before, the keyword mnemonic is really good for learning vocabulary, but you want to keep its use to a minimum. Any word you can remember easily by simpler means is a word you don't have to try and think of a mnemonic for.

Remember too, that learning requires retrieval practice — this is your main strategy. Strategies such as mnemonics are adjuncts. It's all about reducing the number of times you need to practice, and increasing the length of time you can remember for without practice. And understanding is better than artificial connections (which is what mnemonics is about).

So this cognate dictionary is for increasing the number of words you can learn through natural connections.

The dictionary covers 430 cognate clusters, involving 40,000 words in 32 Indo-European languages. These aren't all treated equally, however — I wanted to show the breadth, and get a foothold on the less popular languages (in terms of English native speakers learning other languages — this is not a value judgment!), but the bulk of the words are from the Germanic and Italic (Latin and the Romance languages) branches (of course, this also works in reverse — it's not just about English-language learners of other languages, but also for those learning English as a second language). Here's a breakdown of the numbers:

English: 6378
Latin: 4130
Spanish: 3089
Italian: 3000
Portuguese: 2933
French: 2720

Romanian: 1770
Ancient Greek: 1377
German: 1223
Dutch: 1081
Russian: 907
Old English: 895
Swedish: 892
Norse: 890
Sanskrit: 818
Icelandic: 776
Norwegian: 762
Danish: 743
West Frisian: 601
Modern Greek: 562
Polish: 549
Czech: 490
Lithuanian: 457
Welsh: 422
Slovak: 411
Irish: 389
Albanian: 370
Latvian: 316
Macedonian: 295
Persian: 245
Hindi: 175
Pashto: 69
The dictionary contains the cognate clusters (arranged thematically, and cross-referenced as needed), but also indices for each language, so you can look up a word in your chosen language to find its cognate cluster.
The book isn't just about learning languages, though. There was a lot of very tedious grunt-work involved in putting this together, and I couldn't have done it if I hadn't been sufficiently intrigued by the things I found. If you're interested in words, I think you'll find this dictionary quite intriguing. I certainly did!
By the way, I should note that I was inspired to produce this book when I started listening to the History of English podcast, which begins in those far-off Proto-Indo-European times and moves forward. Great podcast, and Kevin also has transcripts available at his website. Highly recommended!

39-Improving attention
Forget the persistent myth that everything is remembered; that our brains are video cameras whirring away recording everything, and that such 'hidden' knowledge can be brought to light by a hypnotist or alien artefact. Such things are the stuff of fantasy. Of course, there is a nugget of truth there: we can, and do, remember things we've paid no conscious attention to. Sometimes the right question can elicit memories we didn't know we had, in more detail than we imagined we could have. But for the most part, what's not noticed is not remembered. Attention is crucial to memory.
In particular, attention is crucial to good encoding. That is, the construction of memories that will be easily accessed.

In study, of course, we become especially aware of the connection between attention and memory. That's because learning is all about the deliberate construction of accessible memories.
But attention is somewhat of a bugbear: we all recognize its importance, but improving it is no easy task. Nor does research have as much to offer as it might. There are no quick and easy 'fixes' to failing concentration, to the difficulties of focusing on your work when your mind is full of other things.
Here's the most important thing to know when it comes to understanding attention: Attention and working memory are inextricably entwined. Indeed, it's thought that your working memory capacity reflects the extent to which you can control your attention, particularly in situations where there is competing information or competing demands.
In other words, the undeniable differences between people's working memory capacity are not so much because people differ in how much information they can keep active, but because they vary in their ability to control attention.
Controlling attention has two main aspects:

your ability to focus on one thing

your ability to ignore distracting and irrelevant information.

It now seems likely that an erosion in the ability to ignore distraction is the principal reason for the cognitive decline so often seen with age.
Your ability to ignore distraction is also challenged by other circumstances, such as stress and anxiety, sleep deprivation, busy environments.
Improving your attention, then, is a complex task, that should be approached from multiple directions:

Quietening your mind (by reducing your stress and anxiety; by learning how to displace concerns from your working memory; by taking quiet moments; through meditation)

Quietening your environment ('nature breaks' are also helpful)

Understanding how working memory works

Practicing to achieve flow.

40-Similarity
Human memory is a complex and varied phenomenon, and we could delve into its mysteries every day for a hundred years and still have plenty to talk about. But if I had to pick one factor that was absolutely crucial to the operation of memory, I would pick the deceptively simple concept of similarity. Similarity.
We all think we know what that means. An orange is similar to a mandarin; a zebra is similar to a horse; a cup is similar to a glass; my son is similar to his brother. A car is similar to an elephant.
Well, I might think a car was similar to an elephant. Maybe I'm imagining an elephant thundering toward me, kicking up dirt, unstoppable. Or maybe my perceptions are confused. But whether there's a logical reason for my perception of similarity or not, whether my perception of similarity is shared with other people or not, all that is required for my brain to make the connection is ... that I perceive a connection.
Similarity — perceived similarity — is a crucial ingredient to the connections made in your head. Similarity enables us to make connections that transcend space and time, and enables us to strengthen connections made as a result of a juxtaposition of space and time.
Thus, when you meet a person and he tells you his name is Tom Brown, the first connection is made simply because the name and person are coincident in space and

time. And if you leave it there, that connection will most likely be too weak to retrieve on a later occasion.

You can (and should, if you want to remember) employ another critical element to strengthen the connection: repetition (which impacts on the perceived familiarity of the information, but that's another story). But the new information (this person is named Tom Brown) will be much more firmly lodged in your database, and much easier to find, if you make other connections, connections to information already stored in your memory. Thus, you might associate the name with the book "Tom Brown's Schooldays", based on the similarity of names. There might be some physical characteristic of this new person that you can link to a character in the book. If so, you are much more likely to be able to remember this name when you meet the person again. However, if you are barely familiar with the book, and have to stretch your imagination to make any further connection, such as with the characters in the book, then this similarity of names won't greatly help you.

The important thing when connecting new information to information already existing in your database, is to ensure the existing information is itself easily retrievable, and that the connections you make are not too obscure.

So, to make new memories easily retrievable:

look for similarities to existing memories

look for similarities that are obvious to you (what other people think doesn't matter in the slightest)

choose existing memories that are themselves easily retrievable

Appendix C: Text Analyzer Code

Algorithm

```
Global Variables:
TuplesCount: List of (strings,int)
WindowSize: Integer
Punctuation: Boolean
CaseSensative: Boolean
```

```
Function Main:
Step 1: Load text into Text.
        If (NOT Punctuation)
Step 2:   Text <- Remove non-alphabet characters from Text.
        If (NOT CaseSensitive)
Step 3:   Text <- LowerCase(Text).
Step 4: For (i = 0 to Text.Length Step 1)
        Begin
Step 5:   s <- ""
Step 6:   For (j = 0 to j < WindowSize Step 1)
          If (i + j < Text.Length)
Step 7:     s <- s + Text[i + j]
        If (TupleCount contains (s,X))
Step 8:   X <- X + 1
        Else
Step 9:   Insert (s,1) into TupleCount
        End
Step 10: Output TupleCount
```

Appendix D: Travel Distance Calculator Code

Algorithm

```
Global Variables:
Keys: string array of 3 strings
Text: string
```

```
Function Main:
Step 1: Load keyboard layout (Function A).
Step 2: Text <- Load input text (Function B).
Step 3: Text <- Remove non-alphabet characters from the input
text (Function C).
Step 4: TotalTravel <- 0
Step 4: For (i = 0 to Text.Length Step 1)
        Begin
Step 5:   TotalTravel <- TotalTravel +
Distance(Text[i],Text[i+1])
        End
Step 6: Output TotalTravel
```

```
Function A:
Step 1: Open Keyboard.txt in FILE
Step 2: For (i = 0 to 2 Step 1)
        Begin
Step 3:   Keys[i] <- ReadToEnd(FILE)
        End
```

```
Function B:
Step 1: Open Input.txt in FILE
Step 2: T = ""
Step 2: While (not EndOfFile(FILE))
        Begin
Step 3:   T <- T + ReadNextCharacter(FILE)
        End
Step 4: Return T
```

```
Function C:
Step 1: T = ""
Step 4: For (i = 0 to Text.Length Step 1)
        Begin
          If (Text[i] is English Alphabet(in Set {A,…,Z,a…,z))
          Begin
Step 5:     T <- T + Text[i]
          End
        End
Step 6: Return T
```

```
Function Distance (inputs: ch1: character, ch2: character)
```

```
Step 1: For (i = 0 to 2 Step 1)
        Begin
Step 2:    For (j = 0 to 2 Step 1)
           Begin
              If (Keys[i] contains ch1 AND Keys[j] contains
ch2)
Step 3:          Return |indexOfCh1 in Keys[i] - indexOfCh2 in
Keys[2]| + |i – j|
            End
        End
```

C# Code

```
static string[] keys = new string[] { "qwertyuiop", "asdfghjkl", "zxcvbnm" };
static string text = "";

static int Distance(char ch1, char ch2)
{
    int i, j;
    for (i = 0; i < 3; i++)
        for (j = 0; j < 3; j++)
            if (keys[i].Contains(ch1) && keys[j].Contains(ch2))
                return (int)Math.Abs(keys[i].IndexOf(ch1) -
keys[j].IndexOf(ch2)) + (int)Math.Abs(i-j);
    return 0;
}

static void Main(string[] args)
{
    LoadKeyboard();
    ReadInput();
    WriteOutput();
}
```

```

static void LoadKeyboard()
{
    StreamReader sr = new StreamReader("Keyboard.txt");
    for (int i = 0; i < 3; i++)
        keys[i] = sr.ReadLine();
    sr.Close();
}

static void ReadInput()
{
    StreamReader sr = new StreamReader("Input.txt");
    text = sr.ReadToEnd();
    sr.Close();
}

static void WriteOutput()
{
    StreamWriter sw = new StreamWriter("Output.txt");
    string alpha = "abcdefghijklmnopqrstuvwxyz";
    text = text.ToLower();

    string t = "";
    for (int i = 0; i < text.Length; i++)
    {
        if (alpha.Contains(text[i]))
            t += text[i];
    }

    long count = 0;
    for (int i = 0; i < (t.Length -1); i++)
            count += Distance(t[i], t[i + 1]);
    sw.WriteLine(count);
    sw.Close();
}
```