Is Voice Recognition the solution to keyboard-based RSI ?

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ABSTRACT

To determine whether voice recognition is the solution to keyboard-based RSI and to assess its impact and that of other alternative equipment to the standard keyboard and mouse, a survey was undertaken of individuals with RSI.

From a total of 77 respondents, 63 (81%) indicated experience of voice recognition. Comprehensive training was required for the majority but was wholly inadequate or not widely available. Regarding usability, the software could be used in a wide range of applications, but did not provide hands-free access and recognition problems meant continuous error correction was necessary. Programming and graphic work were further highlighted where the software was ineffective.

In conclusion the fieldwork indicated that current voice recognition packages cannot eliminate a keyboard and mouse and can only be considered part of the solution if used in conjunction with an ergonomic keyboard and adaptive support equipment.

Keywords: voice recognition; usability; RSI;

1.0 INTRODUCTION

Repetitive Strain Injury (RSI) is the collective term for a range of work related upper limb musculoskeletal disorders which include Carpal Tunnel Syndrome, Tendonitis and Tensosynovitis, believed to be caused from continuous repetitive movements in an inappropriate working environment.

The explosive growth in computers, has according to Tivey (1997:39) resulted in workers increasingly finding that a computer is necessary in their occupations. The increased dependency on computers raises concerns associated with the continuing rise in the number of injuries arising from long periods of repetitive keyboard work (Nelson et al, 2000: 489).

RSI is not just a problem confined to the UK, where Tudor (1998:5) indicates that government statistics show RSI and back pain are responsible for 10 million days off work annually at a cost to business of around £2 billion. Attaran & Wargon (1999) report 200,000 Americans suffering these conditions and a potential 60 - 120 million at

risk from similar injuries and a survey of 21,500 workers within the European Community (Merllie & Paoli,2000) revealed repetitive work was still widespread, affecting 57%, unchanged from a survey in 1995.

Despite critics questioning the existence of RSI (Larkin, 2000:89; Spillane & Deves, 1987; Bammer & Martin, 1992) other research associates symptoms to muscle and nerve damage (Greening & Lynn, 1998a, 1998b) exacerbated by, and attributed to, a set of complex factors including ergonomics, physical, psychosocial (Faucett & Rempel, 1994; Erdil & Dickerson, 1997; Harvey & Peper, 1997; Tivey, 1997; Cook & Kothiyal, 1998; Sleator et al, 1998; Amell & Kumar, 1999).

With computers part of the standard office furniture, the importance of research into alternative equipment to the keyboard and mouse is emphasised not only by the financial hardship for RSI sufferers but the latest developments in voice recognition software and the determination of the UK government to integrate disabled people into the workplace through legislation (Disability Discrimination Act 1995) and its New Deal rehabilitation scheme.

Given this context this paper explores the computer experiences of users with RSI who have used voice recognition and or alternative ergonomic equipment. Particular emphasis has been placed on the usability and training requirements in relation to voice recognition software in order to evaluate its capability in providing hands free computer access. The survey method was used to assimilate data from users to indicate how the users experiences matched the aspirations of those wanting to use voice recognition software in the workplace.

2.0 BACKGROUND TO RESEARCH

2.1 Limitations of Voice Recognition Technology

Typing is often assumed to be the natural method for data entry; however this is a misconception (Janal 1999:129) as typing has to be taught but virtually everyone knows how to speak. Speech as an interface offers the potential to become more productive with talking speed of 140 words per minute, compared to 50 words per minute for a proficient typist (Janal, 1999:133). However the more immediate advantage is hands-free computing, liberating users from extended keyboard and mouse use and the associated postural constraints (Attaran, 2000:13; Bertuca, 2000:71; Koester & Levine, 2000:549).

Developments in voice recognition technology have been ongoing for over 30 years but the problem remains the inability of a computer to understand human languages and to emulate the human auditory system which is capable of complex analysis. The scale of the challenge is reflected by factors including the make-up of speech e.g. vowel / consonant sounds, silent letters in words, different accents and dialects and the inconsistency of the human voice where emotions and tiredness can affect the speed and tone of speech (Newton, 1985:18).

An enrolment / training process solved the problem of different accents and dialects. A user was required to speak words and phrases in order to create a speech model of the user's vocal characteristics (energy distribution and frequency data of different words). This was stored in a database which was then used in the recognition process.

However the biggest problem remains knowledge of word associations and interpretation and understanding the context of speech. This aspect is crucial in the case of words that sound the same but have different meanings e.g. "too", "two", "to" and "wear", "where" etc. The importance of context in the final decision to select the appropriate word, which cannot be determined from speech sounds alone since it

requires semantics, is reflected in the case of a phrase such as "the book was [red]" which could be "red" in colour or "read" by the teacher (Rodman, 1999:102).

Relatively primitive computer hardware meant early voice recognition systems from the mid 1990s had no ability to perform contextual analysis. These discrete / discontinuous systems were slow and typically unreliable being prone to making wild guesses at words (Koprowski, 1996:37). An unnatural speech input was necessary with pauses required between each word and only 25 - 30 words per minute was achievable (Koester & Levine, 2000:550).

Only the availability of more powerful computer systems in the past 3 - 4 years enabled the development of more complex voice recognition software (Arnold et al, 2000:149). The enrolment process has been enhanced with the time required to input 100 phrases and create a user's speech model, being dramatically cut from 65 minutes to around 10 - 15 minutes with recognition accuracy of 84% - 86% after this process (Gann, 2000:107). Continuous speech can now be accepted and the latest systems have some natural language understanding and ability to perform some contextual analysis (Bertuca, 2000:71; Cravotta, 1999:80).

2.2 Use of Voice Recognition Software

The latest voice recognition software systems have vocabularies of up to 300,000 words (Griffith, 2000:25) and are compatible with both Unix and Windows operating systems. High end packages can perform many functions including continuous speech into most Windows applications and command and control of the desktop environment, including moving between applications, dropping menus, controlling applications and physical devices such as a printer. The ability to search the Internet and dictate and send e-mails has further been incorporated.

In terms of usability, Griffith (1998, 1999, 2000) and Bertuca (2000) highlight some of the most productive features that include navigation facilities through a document with commands such as "go to the fifth paragraph" and editing commands to select, copy, cut and paste text within the same or different documents or applications. Formatting is enhanced with the ability to say "justify the paragraph" or " underline the next two lines" which is considerably faster that using a keyboard or mouse. Macros and scripts can further be developed to voice enable any Windows applications, providing short cuts for cutting, pasting etc. Correcting recognition errors is straightforward with the provision of a correction window that lists alternative words that can be selected and a spell facility. When a correction is made, the software updates a speech data file that enables it to determine the correct word in future. Tool kits are also available that further allow voice recognition to be used on a network and to enable speech developers to create their own voice commands for different applications, including programming in Visual Basic, Delphi and C++.

The latest voice recognition software has the ability to filter out background noise but inexpensive microphones and sound cards supplied with most computer systems are unsuitable, undermining recognition accuracy. However, both sound card and microphone technology has improved generally. Noise cancelling microphones contained in a headset are now supplied with most voice recognition packages.

For integration into an office environment the complexity of the voice recognition software necessitates for optimum performance a 450 Mhz machine with 250 MB Ram (Griffith, 2000:28). A location away from windows, concrete walls (reflected sound can cause echoes) and the noise of co-workers and telephones is required. Research by Goette (1998:195) highlights the problem of ambient noise seriously undermining voice recognition performance and resulting in the unsuccessful implementation for some

individuals.

Research by Schwartz & Johnson (1999); Goette (1998, 2000) further concludes that for successful implementation of voice recognition a comprehensive training programme is necessary. Attaran (2000:42); Bertuca (2000:70); Griffith (2000) warn that considerable motivation and patience is required to achieve a recognition accuracy of around 95%. Individuals may require between 12 and 50 hours work to become productive involving macro creation and stringent error correction in order to obtain a good voice profile and establish a comprehensive vocabulary. Vocal strain is a potential risk (Griffith, 2000:23) especially for the disabled, due to the voice being used more because of the inability to use a keyboard and mouse. Consequently, additional training by a vocal instructor may be required to learn appropriate breathing and speaking techniques.

In conclusion the literature indicates that providing an evaluation of the computer hardware and working environment is undertaken and comprehensive training is made available, the latest voice recognition software packages provide a viable alternative to the standard keyboard and mouse in most applications. Therefore individuals suffering with upper limb disorders such as RSI could possibly have effective access to a computer.

3.0 METHODOLOGY

3.1 Survey Method

A survey using a questionnaire and interviews was undertaken. Hill (1995:130) indicated this method would obtain aspects of usability including user preference and attitudes towards an interface / feature.

A questionnaire was used as the primary source of data collection because unlike an interview, a wider subject group could been reached, and the data could be analysed more easily (Sarantakos, 1998:224; Hill, 1995:130).

Interviews were used as a follow-up process to validate data obtained from the questionnaire. According to Frankfort-Nachmias & Nachmias (1992:216) answers in the questionnaire have to be accepted as final with no opportunity to explore further any issues or to clarify any ambiguities. A structured interview using the questionnaire as the basis of the interview was selected to provide “pre-prepared questions in a pre-planned structure, without divergence” (Cornford & Smithson, 1996:102). An unstructured interview where a topic is provided and the conversion takes place without any planning could result in divergence from the subject area.

As suggested by Cornford & Smithson (1996:100); May (1997:93) a pilot survey of the questionnaire was undertaken. This was to ensure that the questionnaire was understandable and that all ambiguities were identified and eliminated. Four participants took part in this process.

3.1 Survey Approach

An advertisement was placed in the quarterly newsletter of the UK RSI Association in order to find computer users with experience of voice recognition software and / or alternative equipment to the standard keyboard and mouse. RSI support groups within the UK and US were further contacted via an initial contact letter or e-mail outlining the purpose of the questionnaire offering a copy of the final report together with an assurance of confidentiality. A stamped addressed envelope was also included with each posted questionnaire.

To increase the size of the survey the questionnaire was used to create an on-line poll which various RSI support groups in the US advertised on their website. A total of

77 participated in the survey, conducted via the questionnaire, interviews and the on-line poll.

3.2 Questionnaire Design

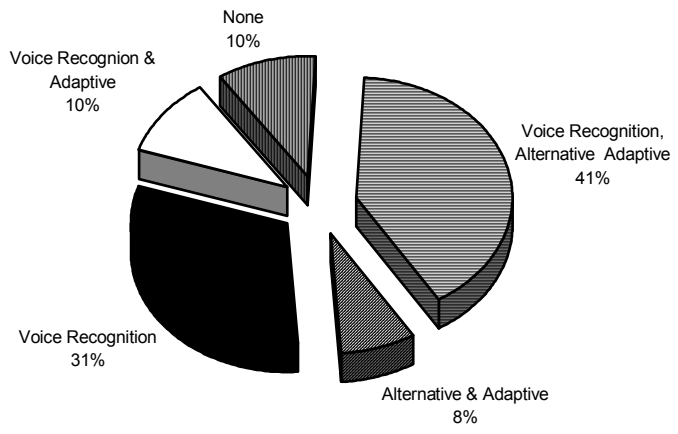
The development of the questionnaire was from an extensive literature review of books and papers relating to aspects of usability, training concerning voice recognition and alternative ergonomic equipment to the standard keyboard and mouse.
The questionnaire was split into questions focusing both on quantitative data - equipment used, training received, applications used and qualitative data regarding the perceived benefit of the equipment with regard to providing effective computer access and the ability to continue or return to work.

4.0 SURVEY RESULTS

4.1 Equipment

Figure 1 shows the different combinations of voice recognition, alternative and adaptive support equipment used by respondents. A total of 69 out of the 77 respondents indicated that they had used one or more devices in order to provide effective access to a computer. 63 respondents (81%) have or currently use voice recognition software.

Figure 1 - Equipment used by Individuals with R.S.I in order to access a Computer



From a total of 37 respondents who had alternative equipment, 33 had an ergonomic keyboard whilst of the remaining four respondents, two indicated a modification of a hot / sticky key set-up to their standard keyboard. 23 of the 37 respondents also had one or more replacement devices for the standard mouse. In addition to voice recognition software and / or alternative equipment 55 respondents had adaptive computer equipment as shown in Figure 2.

Figure 2 - Adaptive Support Equipment required

Equipment	No of Individuals
Arm Rests	2
Document Holder	3
Ergonomic Chair	34
Foot Stool	20
Keyboard Tray	5
Monitor Platform	5
Lumber / Back Support	15
Keyboard /Mouse Wrist Rests	16
R.S.I Guard Software	1
Slanting Work Surface	1
Wedge Cushion	1
Wrist / Arm Splints	10

4.2 Voice Recognition Software

4.2.1 Training

Only 10 of the 63 respondents (16%) were offered the opportunity at work to use voice recognition software for a trial period. Regarding actual training in areas such as the microphone set-up, installation, enrolment, navigation and macro creation only 27 respondents (43%) received any form of training (Figure 3).

Figure 3 - Voice Recognition Training received

Type of Training	No of Individuals
Course	8
Manufacturer's Demonstration	3
Personal Tuition	12
Technical Support	1
Written Exercises	1
Unspecified	2

However 22 of the remaining 36 respondents who did not receive any training indicated it was required in the specific areas identified in Figure 4.

Figure 4 - Training Required

Type of Training	No of Individuals
Installation / Microphone Set-up	7
Internet Use	1
Longer Technical Support	1
Navigation / Macro Creation	12
Vocal / Speaking Techniques	3

4.2.2 Software Applications

The applications to which voice recognition software are most commonly applied is detailed in Figure 5. The most common applications for voice recognition indicated by 63 respondents were word processing (97%), e-mails (33%), the Internet (30%) and spreadsheet work (17%). The extent to which the capabilities of voice recognition has advanced from word processing is reflected by several respondents who used voice recognition for virtual reality work, programming and command and control in Unix, Windows 95 and NT operating system environments.

Figure 5 - Applications / Programs in which Voice Recognition is used

Application / Software Package	No of Individuals
PC Based Database Work	3
Desktop Navigation	7
E-mail	21
Environmental Controls	1
Internet Providers	19
Mainframe Systems	3
Organiser	7
Presentation Software	1
Programming	2
Spreadsheets	11
Statistical Analysis	1
Network Security Management	1
Project Management	1
Unix Operating System	1
Virtual Reality	1
Windows 95 / NT Operating System	3
Word Processing	61

4.2.3 Usability

Despite the capabilities of voice recognition, a mouse had to be used in conjunction with software by 44 respondents (70%). Furthermore 55 respondents (87%) found a keyboard was necessary in the applications / operations identified in Figure 6.
The applications and operations, where use of a keyboard was still required by most respondents, included the Internet (24%), e-mail commands (22%), word-processing - deleting and editing text (16%), desktop navigation, graphic design work and programming (11%).

Figure 6 - Applications / Operations where a Keyboard is still necessary

Application / Operations	No of Individuals
A Single Key Press	2
Activating & Shutdown Software / PC	5
Desktop Navigation	6
E-mail	12
File Management	4
Graphic Work/ Computer Aided Design (C.A.D)	6
Help Systems	1
Internet Providers	13
Interactive Programs / Games	2
Multimedia Work	1
Numeric Data Entry	1
Operating System Commands	2
Organiser	1
Password Entry	1
Programming	6
Scanning	2
Specialist Scientific Software	2
Spreadsheets	2

Unspecified	**16**
Unix / Linus Operating Systems	**1**
Word Processing	**9**

The survey provided an opportunity for respondents to indicate whether any problems were experienced, and if re-training in the package was still necessary to enhance recognition accuracy. Of 63 respondents, 61 indicated the problems listed in Figure 7.

Figure 7 - Problems Experienced using Voice Recognition

Problem	No of Individuals
Application Crashes / Freezes	**1**
Background Noise	**5**
Installation Errors	**1**
Slow Operation	**4**
Unable to Open Web Pages	**1**
Unrecognised Commands	**35**
Unrecognised Numbers / Words	**45**
Unspecified	**12**

The most common include unrecognised numbers / words (74%), unrecognised commands (57%), background noise undermining recognition accuracy (8%) and slow operation (7%). Unrecognised words and commands may explain why 57 out of 63 respondents (90%) are continually retraining the software to improve recognition accuracy. Only eight respondents indicated difficulty retraining, although 10 of the remaining 49 respondents did comment that this activity was time consuming.

With regard to abandoning voice recognition 16 out of the 63 respondents (25%) indicated that at some time they had abandoned use of the software with seven respondents discontinuing use for all activities on the computer. The reasons are identified in Figure 8. The most significant reasons for not using voice recognition indicated by respondents was damage / strain to vocal chords from continually speaking, frustration and requiring a more powerful computer with which to run the software.

Figure 8 - Reasons for Abandoning Voice Recognition

Reason(s)	No of Individuals
Damage / Strain To Vocal Chords	**7**
Frustration	**5**
Limited Sitting Tolerance	**1**
Required A More Powerful PC	**3**
Technical Problems with PC & Voice Rec	**1**
Unspecified	**4**
Until Training Was Provided	**1**
Voice Recognition Too Slow / Inaccurate	**1**

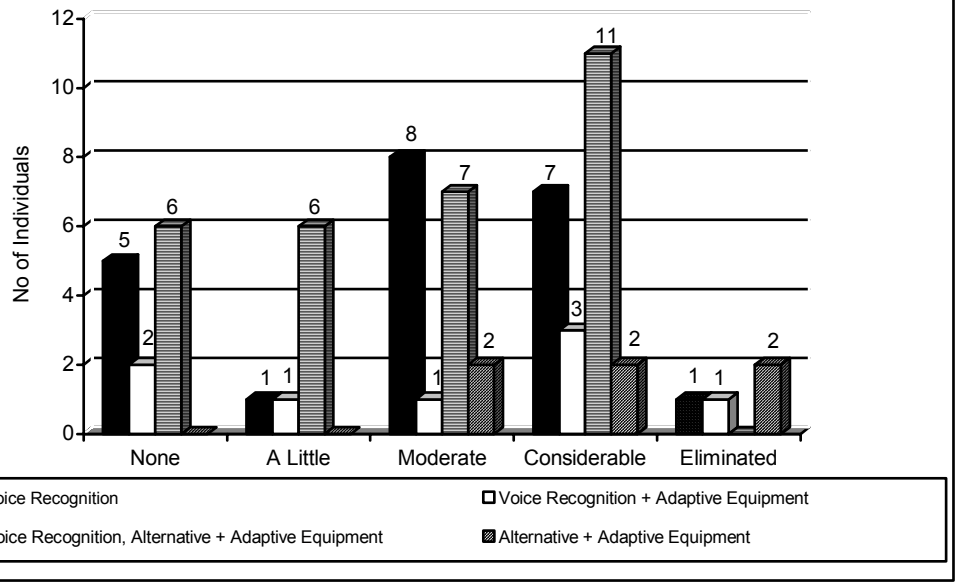
4.3 Impact of Voice Recognition and Alternative Ergonomic Equipment

4.3.1 Impact on pain and the ability to work

Of the 69 respondents that used voice recognition, alternative or adaptive computer

equipment, 66 (96%) indicated that there was an impact on pain (Figure 9).
For 21 of the 66 respondents (32%), use of voice recognition software with or without

Figure 9 - Impact of Voice Recognition, Alternative and Adaptive Equipment on Pain Experienced

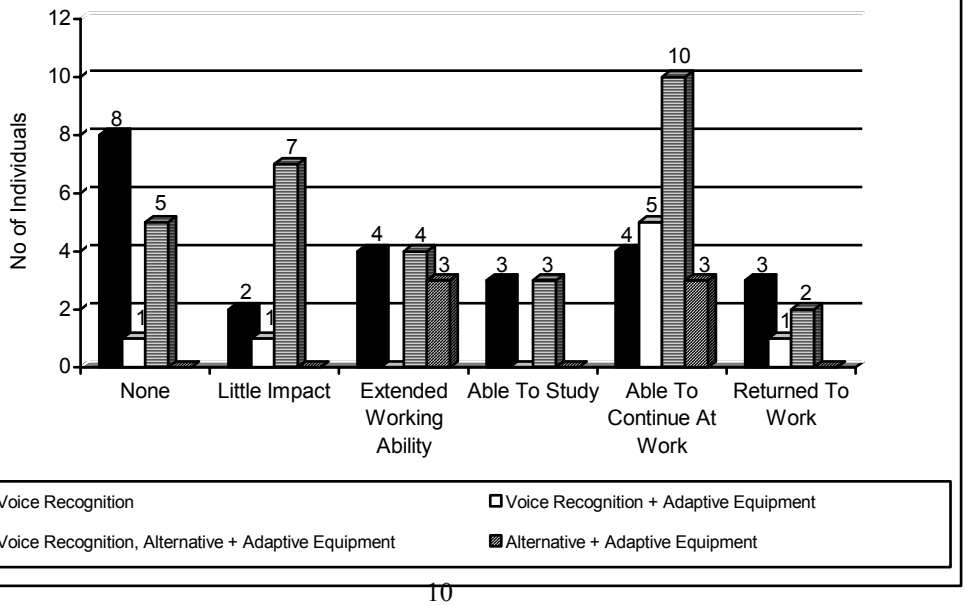


alternative and / or adaptive equipment, little or no difference in pain was experienced. However for 23 respondents (32%) this equipment resulted in considerable pain reduction, and four other respondents (6%) reported that the pain was completely eliminated.

The overall effect for 40 respondents (61%) was that they could perform more tasks on a computer than before the equipment was installed. The subsequent impact on the ability of respondents to work is indicated in Figure 10.

For 24 of the 69 respondents (35%) use of voice recognition, alternative and / or

Figure 10 - Impact of Voice Recognition, Alternative and Adaptive Equipment on Working Ability



adaptive equipment made little or no impact on their ability to use a computer. However for 45 respondents (65%), this equipment had a significant impact. In particular, six respondents (9%) were able to use the computer for study and for 22 respondents (32%) the equipment enabled them to remain working, another six (9%) were able to return to work.

4.3.2 Attitude towards equipment

Eight of the total 77 respondents did not have voice recognition software or any ergonomic equipment. When asked to select equipment they felt would provide them with effective computer access, six respondents indicated a preference. Three respondents choose voice recognition software principally to avoid using a keyboard and three choose an ergonomic keyboard from the point of view that voice recognition was impractical in a noisy office environment.

Despite mixed responses, the benefits of both voice recognition and ergonomic keyboards were more favourable with respondents who had actually used them. A significant improvement was reported from the respondents who actually used an ergonomic keyboard with the ability to type for long periods remaining pain free and enabling them to continuing working, which was not possible using a standard keyboard. Furthermore several respondents commented that voice recognition software eliminated the need for a keyboard and provided effective computer access which for some was previously impossible. Crucially, for one respondent, the software had enabled them to work part-time, after eight years of unemployment.

5.0 DISCUSSION

5.1 Voice Recognition Training

Despite the importance researchers have placed on training for the successful implementation of voice recognition software (Griffith, 1998, 1999, 2000; Goette, 1998, 2000; Schwartz & Johnson, 1999) the survey results suggest training provided by the software developers and training companies is either inadequate or not widely available. Although the findings support the need for comprehensive training only 20 of the total 63 respondents (32%) received what can be considered proper training in the form of a course and / or personal tuition. A further seven respondents indicated that training received ranged from an hour with the engineer who installed the software to one or two days basic training. All these modes of training were considered insufficient. Of the remaining 36 respondents (57%), who received no training whatsoever, 22 (35%) indicated it was required covering most aspects of voice recognition including error correction, navigation and macro creation (regarded by one respondent as crucial to the software's operation). A lack of understanding of the software's capabilities and poorly written or inaccurate documentation was cited as reasons why five abandoned the software due to frustration.

The importance of vocal training (Griffith, 2000:28) is reinforced by seven respondents who abandoned the software because of damage / strain on their vocal chords. The serious risk of this injury is highlighted by one respondent who lost his voice for three weeks after using the software for only two; he indicated that his voice has never fully recovered.

Certainly the survey results suggest that more action is necessary by software developers to provide comprehensive training or at least to emphasise its importance and recommend an appropriate training company. Employers could also do more to provide opportunities for employees to attend training courses through flexibility in working arrangements, and in regard to work loads, in order for individuals to become

proficient with the software. Research by Goette (2000:75) highlights the lack of co-operation by employers in regard to work loads and deadline extensions for training resulting in some individuals abandoning voice recognition and reverting back to typing instead of taking the additional time necessary to complete a task using the voice recognition software.

5.2 Usability of Voice Recognition

The survey results highlight the extent to which the voice recognition software capabilities have advanced beyond word-processing. It is used in a wide range of applications including databases, spreadsheets, virtual reality work, on the Internet and programming.

Despite the need for training, the findings indicate voice recognition is far from reliable in terms of recognition accuracy. Griffith's (1998, 1999, 2000) assertion that stringent error correction is required is supported by 61 out of 63 respondents (97%) that reported continually re-training and correcting errors. Although 49 respondents (80%) indicated this process was time consuming, for most it was deemed relatively easy.

The survey results also indicated that voice recognition software was far from providing complete hands-free computer access. A keyboard and mouse were still required for most applications including e-mails, the Internet, deleting / editing text, programming and graphics work (where extensive mouse use is necessary). Programming, in particular, was the area where the software has not yet provided effective access. Although tool kits are available not all computer languages e.g. Ada, Pascal have been incorporated. One respondent complained about the lack of a voice recognition solution for C programming in either a Unit or Linux environment. Another respondent that attempted to use the software for programming commented that with the large number of symbol characters it was far more efficient to simply type them. However, research into programming via voice recognition continues. Arnold et al (2000) illustrate work on developing environments to enable programming by voice.

Overall the fieldwork supports the conceptual view taken in the literature (Attaran, 2000; Bertuca, 2000; Cravotta, 1999; Griffith, 1998, 1999, 2000; Goette, 1998, 2000) regarding the usability and effectiveness of the latest voice recognition packages. The need for comprehensive training was confirmed and the software's capabilities emphasised by the wide range of applications to which it could be applied.

However the fieldwork also indicated that the software was far from perfect particularly in regard to recognition accuracy with continuous re-training / error correction required and the inability to provide complete hands-free computing. Despite this, use in conjunction with an ergonomic alternative to the standard keyboard and mouse, together with adaptive support equipment, has provided some respondents with an effective solution. A majority, 48 of 69 respondents (70%) reported some reduction in pain and crucially for 22 respondents this equipment enabled them to continue working and, for a further six, the opportunity to return to work.

Arnold et al (2000) points out that voice recognition software has improved enormously primarily to the vast increase in computational power. Continuing developments in computer systems now with 2GHz processors provide the opportunity to develop more complex voice recognition software packages with the possibility of greater reliability and facilities for effective use in areas such as programming and graphic design. The scope for future research is emphasised by a current 3 year study (Koester & Levine, 2000) exploring usability aspects of voice recognition covering such issues as the learning curve and productivity. The conclusions from this and other

research may influence the direction of voice recognition development.

6.0 CONCLUSION

This paper set out to determine the computer experience of individuals with RSI and, in particular, whether voice recognition software provides the solution to keyboard based RSI, facilitating effective access to a computer. Although the broad concept of voice recognition has the potential to provide hands-free computer access, currently the technology is still some way from achieving this goal. The survey findings indicate that a keyboard and mouse are still necessary for most applications and that voice recognition software cannot yet be fully utilised for programming and graphic design work. For successful implementation of voice recognition software, a considerable amount of time is required to build a comprehensive voice profile and enhance recognition accuracy involving stringent error correction. The survey findings also highlight the need for training covering all aspects of the software. An evaluation of the working environment and computer hardware is also necessary to eliminate background noise that can seriously degrade voice recognition accuracy.

The conclusion from this research is that voice recognition software can only be considered part of the solution to providing effective computer access. The other important components are an ergonomic keyboard, mouse and adaptive support equipment. The findings from the survey also indicate that a combination of this equipment has enabled some individuals to either return to or continue to work.

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REFERENCES

Amell, T.K., Kumar, S., 1999. Cumulative trauma disorders and keyboarding work. International Journal of Industrial Ergonomics 25 (1), 69-78.

Arnold, S.C., Mark, L., Goldthwaite, J., 2000. Programming by Voice VocalProgramming. In: ACM SIGCAPH Conference on Assistive Technologies. The fourth International ACM Conference on Assistive Technologies. Arlington, Virginia, 13-15 November, pp. 149-155.

Attaran, M., Wargo, B.D., 1999. Succeeding with ergonomics in computerised offices. Work Study 48 (3), 92-99.

Attaran, M., 2000. Voice recognition software programs: are they right for you ?. Information Management and Computer Security 8 (1), 42-44.

Bammer, G., Martin, B., 1992. Repetition Strain Injury in Australia: Medical Knowledge, Social Movement, and deFacto Partisanship. Social Problems 39 (3), 219-237.

Bertuca, D.J., 2000. Voice recognition software and OCLC technology that works. OCLC Systems and Services 16 (2), 69-75.

Cornford, T.R., Smithson, S., 1996. Project Research In Information Systems - A Student's Guide. Basingstoke: MacMillan Press.

Cook, C.J., Kothiyal, K., 1998. Influence of mouse position on muscular activity in the neck, shoulder and arm in computer users. Applied Ergonomics 29 (6), 439-443.

Cravotta, N., 1999. Speech Recognition: It's not what you say; it's how you say it. EDN 44 (13), 79-88.

Department for Education and Employment, 1999. The Disability Discrimination Act 1995 - What Employers Need To Know - DL170. London: HMSO.
Erdil, M., Dickerson, O.B., (eds) 1997. Cumulative Trauma Disorders. Prevention, Evaluation and Treatment. New York: Van Nostrand Reinhold.
Faucett, J., Rempel, D., 1994. VDT-Related Musculoskeletal Symptoms: Interactions Between Work Posture and Psychosocial Work Factors. American Journal of Industrial Medicine 26, 597-612.
Frankfort-Nachmias, C., Nachmias, D., 1992. Research methods in the social sciences 4th ed. London: Edward Arnold.
Gann, R., 2000. His Master's Voice. Personal Computer World, January, 106-112.
Goette, T., 1998. Factors Leading To The Successful Use Of Voice Recognition Technology. In: ACM SIGCAPH Conference on Assistive Technologies Proceedings of the third International ACM Conference on Assistive Technologies. Marina del Rey, California, January, pp. 189-196.
Goette, T., 2000. Keys to the Adoption and Use of Voice Recognition Technology in Organisations. Information Technology and People 13 (1), 67-80.
Greening, J., Lynn, B., 1998a. Vibration sense in the upper limb in patients with repetitive strain injury and a group of at-risk office workers. Internal Actives of Occupational and Environmental Medicine 71, 29-34.
Greening, J., Lynn, B., 1998b. Minor peripheral nerve injuries: an underestimated source of pain ?. Manual Therapy 3 (4), 187-194.
Griffith, R.L., 1998. Speech Recognition Software for Injury / Disability / Prevention. In: Proceedings of the Silicon Valley Ergonomics Conference and Exposition - ErgoCon '98. Silicon Valley Ergonomics Institute, San Jose State University, San Jose, California, 3-6 May, pp. 119-124.
Griffith, R.L., 1999. Speech Recognition Training for Prevention and Productivity. In: Proceedings of the Silicon Valley Ergonomics Conference and Exposition - ErgoCon '99. Silicon Valley Ergonomics Institute, San Jose State University, San Jose, California, 1-4 June, pp. 199-203.
Griffith, R.L., 2000. Talking Computers in the 21st Century: Speech Recognition Coming to a Computer near You. In: Proceedings of the Silicon Valley Ergonomics Conference and Exposition - ErgoCon 2000. Silicon Valley Ergonomics Institute, San Jose State University, San Jose, California, 5-7 June, pp. 27-31.
Harvey, R., Peper, E., 1997. Surface electromyography and mouse use position. Ergonomics 40 (8), 781-789.
Hill, S., 1995. A Practical Introduction to The Human Computer Interface. London: Guernsey Press.
Janal, D.S., 1999. Business speak - using speech technology to streamline your business. New York: John Wiley & Sons.
Koester, H.H., Levine, S.P., 2000. User Performance With Continuous Speech Recognition Systems. In: Technology for the new millennium, Proceedings of the RESNA 2000 Annual Conference. Orlando, Florida, 28 June-2 July, pp. 549-554.
Koprowski, G., 1996. Hello is anyone there ?. New Scientist 18 May, pp. 36-39.
Larkin, P., 2000. Social Security - Compensation for Repetitive Strain Injury. Industrial Law Journal 29 (1), 88-95.
May, T., 1997. Social Research: issues, methods and process, 2nd ed. Buckingham: Open University Press.
Merllie, D., Paoli, P., 2000. Ten Years of Working Conditions In the European Union. European Foundation for the Improvement of Living and Working Conditions.
Nelson, J.E., Treaster, D.E., Marras, W.S., 2000. Finger motion, wrist motion and

tendon travel as a function of keyboard angles. Clinical Biomechanics 15 (7), 489-498.
Newton, S.J., 1985. Voice in office systems, Manchester: The National Computing Centre Limited.
Peters, L., 2001. All talk. Computer Active, 25 January, pp. 60-65.
Rodman, R.D., 1999. Computer speech technology. Norwood: Artech House.
Sarantakos, S., 1998. Social Research, 2nd ed. Basingstoke: Macmillan.
Schwartz, P.J., Johnson, J., 1999. The Effectiveness of Speech Recognition Technology. In: Spotlight on Technology Proceedings of the RESNA '99 Annual Conference. Long Beach, California, 25-29 June, pp. 77-79.
Sleator, A., Gore, D., Vidler, G., 1998. Work Related Upper Limb Disorders. London: House of Commons Library.
Spillane, R., Deves, L., 1987. RSI; Pain, Pretence or Patienthood ?. Journal of Industrial Relations 29 (1), 41-48.
Tivey, H., 1997. RSI Hazards Handbook - A workers' guide to Repetitive Strain Injuries and how to prevent them. London: London Hazards Centre Trust.
Tudor, O., 1998. Safety Rep survey: back strain and RSI the hidden workplace epidemics. London: Trade's Union Congress.