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Searching for Information on PDA in a Naturalistic Environment with or without Music

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ABSTRACT

The present paper investigates the effects of different kinds of music on information searching in a crowded cafeteria. Our experiment employs four texts that differ in length only, not in content or syntactic complexity. Each text is loaded on a web page and displayed on a PDA. We ask to participants 20 questions about each text and then compare their accuracy and performance time. Participants carry out their task in three different background conditions: normal environmental noise, earphones with classical symphonic music or earphones with modern Italian songs. We assume that classical symphonic music improves information searching by isolating the participant from the noise and background chitchatting of the cafeteria, while modern Italian music compromises performance, because processing the lyrics interferes with the task. In line with our expectations, classical music significantly improves information searching, but contrary to our hypotheses, Italian music improves performance, although not in a significant way. We conclude that in a situation with background noise, listening to classical music increases the speed of information searching with respect to a condition without music.

Keywords: *PDA, Searching for information, Background music, Noise, Irrelevant speech, Information processing, Arousal.*

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1. Introduction

Mobile technologies play a central role in today's world (Schaffers, Brodt, Pallot, & Prinz, 2006). The advantage of mobile technology is that you can always carry it with you. A palmtop, more than a laptop, can be carried anywhere. Such mobile devices are often used by those who travel because of their profession. Therefore, PDAs are generally employed in dynamic and noisy environments in which users are moving (MacKay, Dearman, Inkpen, & Watters, 2005).

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Mobile technology has recently added web browsing that provides PDA access to web information. The Internet offers all kinds of information. When most people surf the web with their PDA, they are not looking for complex information that requires longer time to be found and a full-size desktop screen to be displayed. Instead, "the searching behavior supported by PDAs tends to be one in which the user seeks specific information" (Kim & Albers, 2001, p. 193) in noisy and crowded environments. For instance, while having breakfast or lunch in a cafeteria, people may like to read the daily news. They need to find the right website among many online newspapers. In such a situation, the PDA user is typically more exposed to background noise (in particular, background conversation) than the PC user in an office. Recently, Kallinen (2004) conducted a study in which participants in a noisy environment read texts on PDA when listening to music with earphones. The data obtained demonstrate that music not only improves reading abilities by reducing distraction and enhancing attention but also increases positive emotional responses and the level of general satisfaction. According to Kallinen, music enhances the social richness of the medium "because it increases one meaningful information channel (i.e., music instead of background noise)" (p. 1227). But when searching for information on a small screen display, does listening to music facilitate the performance, or cause more errors? Moreover, are the accuracy and the performance time influenced by the kind of music?

This paper attempts to answer these questions. There is a lack of studies on searching for information on PDA in ecologically valid realistic settings[1]. Our study investigates information retrieval in a web page displayed on PDA in an ordinary environment with different background conditions.

2. Experiment

2.1 Study Design

There are three variables in our experiment:

- background condition (without music, with classical symphonic music, and with Italian music);
- length of the body of the text (450, 550, 650, and 800 words);

[1] Kim and Albers (2001) focus on the differences between handheld and desktop interfaces and explore ways in which design of handheld may affect information retrieval; however, the experimental setting is not naturalistic.

- location of key information within the body of the text (beginning, middle, and end).

The location of the key information is a within-subjects factor, whereas the other two variables are handled between-subjects. Since the aim of our research is to investigate the effects of different kinds of music on information searching, the background condition is the main independent variable. We have employed texts of different lengths with different positions of the key information, because there could exist some interaction between these variables and the background condition.

2.2 Background Condition

When searching for textual information, one must focus on the task of searching, without being distracted by the external environment. After the desired information is found, one must decide if it is correct and exhaustive enough. The information should be repeated, so that it can be maintained in the conscious workspace, until it is stored in the long-term memory, or written somewhere (on a spreadsheet, for instance). Furthermore, most information cannot be found directly "but by narrowing the search down based on implicit relationships between what the person is currently viewing and what is desired" (Kim & Albers, 2001, p. 195). These cognitive capacities could be affected by external stimuli such as noise or music.

Noise

There are different kinds of noise. White noise[2], road traffic noise, meaningless irrelevant speech, and meaningful irrelevant speech are the most common and studied. The former two are nonverbal, whereas the latter two are verbal.

Immediate serial recall declines in the presence of meaningless and meaningful irrelevant speech but is unaffected by white noise (Rouleau & Belleville, 1996).

Studies of irrelevant speech and short-term memory underline marked impairment from both meaningful and meaningless speech, particularly on memory tasks with a serial component (e.g., Martin, Wogalter, & Forlano, 1988; Jones, Miles, & Page, 1990; Oswald, Tremblay, & Jones, 2000; Tremblay, Nicholls, Alford, & Jones, 2000). In reading comprehension tasks, meaningful irrelevant speech is more disruptive than irrelevant speech without meaning (see Martin et al., 1988; Smith, 1989; Oswald et al., 2000).

[2] White noise is defined as 'the effect of the complete range of audible sound-wave frequencies heard simultaneously, analogous to white light, which contains all the frequencies of the light spectrum' (*Encyclopedia Britannica,* 2007).

A recent study (Boman, Enmarker, & Hygge, 2005) summarizes the data of three separate previous experiments (Hygge, Boman, & Enmarker, 2003; Boman, 2004; Enmarker, 2004) performed with the same experimental design. The results show that, in the reading comprehension task, cued recall and recognition are more impaired by meaningful irrelevant speech than by road traffic noise. Moreover, the obtained noise effects are not related to the participants' capacity to perform the task; indeed, there is no interaction between the noise and age groups.

There are at least three different possible explanations to these results:

1) The semantic character in speech interferes with the semantic content in the material to be processed, especially for cognitive complex tasks. Indeed, irrelevant speech could be regarded as an additional task, making the situation comparable with divided attention situations where multiple stimuli must be processed simultaneously (Smith, 1985; Oswald et al., 2000).

2) The critical aspect of the noise causing irrelevant speech effects is neither its meaningfulness nor its linguistic character but the auditory signal that exhibits distinct acoustic variation or changes between its components (Jones, Madden, & Miles, 1992).

3) An auditory verbal background interferes with the retention of visually presented text, because under normal conditions both types of material have access to the *phonological store*[3] (Baddeley, 1986, 1990); therefore, one may impede the other. Thus, the irrelevant speech effect occurs at the level of the phonological store and is unrelated to the acoustic quality of the stimuli (Colle, 1980) and the semantic content of the verbal noise (Salamé & Baddeley, 1982). However, "recall is affected by auditory stimuli that include a verbal component, as is the case with speech or songs, but it remains intact when the auditory stimuli are nonverbal, as is the case with white noise" (Rouleau & Belleville, 1996, p. 357).

To summarize, irrelevant speech is more disruptive in a cognitive task than white noise and road traffic noise.

Music

Some studies suggest a disturbance of background music to message processing (e.g., Furnham & Bradley, 1997). According to our hypotheses, this effect is related to the kind of music. With classical symphonic music background, there should not be

[3] In working memory, the *phonological loop* includes a *phonological store* where verbal information is held in a phonological code. Since the phonological store is time-limited, a rehearsal procedure is used to prevent material from decaying. This procedure is also used to transfer the written digit into the phonological store (see Baddeley, 1986, 1990).

interference with the information search, given that there is no linguistic message to be processed. Italian music leads one to process the lyrics; such processing happens in a superficial way, according to the paradigm of *attenuated processing* (Eysenck & Keane, 1990). This processing is also an elaboration of lyric meaning and could interfere with the information search, subtracting attentional resources or complicating information maintenance in working memory.

Music itself should not interfere with the task, but the meaning present in the lyrics should. For this reason, in the present study we compare classical symphonic music by different composers (Haydn, Mozart, and Beethoven) with songs by modern Italian songwriters (De André, Battisti, Guccini, and De Gregori). Italian is the language of the participants.

Predictions

It is reasonable to anticipate that classical symphonic music improves the performance of information searching, because it suppresses meaningful irrelevant speech. Indeed, the condition without music is characterized by the presence of meaningful irrelevant speech, because the experimental setting is a crowded cafeteria and, therefore, many linguistic messages are present. On the contrary, we expect that Italian music impairs the performance of information searching, because there is only one linguistic message that is very clear. Therefore, the condition with Italian music is expected to produce more impairment than the condition without music, which is expected to produce more impairment than the condition with classical symphonic music.

2.3 Hypotheses

There are five experimental hypotheses in this study:

H_1: Participants' performance (accuracy and speed) declines when the text length increases. Moreover, participants should have more difficulty finding information in the middle and in the end of web pages than at the beginning. These findings should be more extreme in the Italian music condition.

H_2: Participants should exhibit fewer errors when they search for information while listening to classical symphonic music than while searching without music.

H_3: Participants should take less time to perform the same tasks when they search for information while listening to classical symphonic music than when searching without music.

H_4: Participants should exhibit more errors when they search for information while listening to Italian music than in other conditions.

H_5: Participants should take more time to perform the same tasks when they search for information while listening to Italian music than the other conditions.

Hypotheses 2 and 3 suppose that classical symphonic music improves information searching, while hypotheses 4 and 5 suppose that Italian music decreases performance.

2.4 Participants and Location

The experimental subjects are 24 Italian native speakers (10 males and 14 females), with varying educational backgrounds, ranging from 18 to 38 years of age. All participants have normal or corrected-to-normal vision. They were unaware of the purpose of the experiment. After the experiment, some participants received food incentives for their participation, since the environment was a cafeteria.

The participants were randomly assigned to one of three independent groups: without music, with classical symphonic music, or with Italian music. Each group consists of 8 participants.

The experiment was conducted in a comfortable, well-lit cafeteria in Padua centre during lunch time to ensure that participants would be exposed to similar levels of noise. Participants used a Qteck 9000 Pocket PC. Each participant had time to be comfortable with the mobile device. The Pocket PC was held in their hands or put on the coffee table and used with a stylus pen. Answers were given using the PDA keyboard. Participants listened to the music with earphones.

2.5 Materials

Texts

The 800-word article “Fornarina, Velata o Galatea” by Corriere della Sera (Bonazzoli, 2006) was gradually shorted by eliminating words that did not interfere with the overall meaning of the article itself to obtain the other three texts of different lengths (650, 550, and 450 words). According to the Flesch-Vacca scale[4] (Vacca & Franchina,

[4] To evaluate the *readability* from the syntactic point of view, you consider the length of some linguistic units (sentences and words), that make up the text, as a factor that indicates how difficult a reading passage is to understand. The sentences and words length is used as a linguistic variable in many statistic *readability index*. One readability index is a mathematical formula that, thanks to a statistic calculus, predicts the text complexity, using a specific scale of values.
In our study we use the *Flesch index* (Flesch, 1948). To apply this index you only need the average sentence length (total words/total sentences) and the average number of syllables per word (total

1986), all four texts can be considered as *easy*. In other words, they do not differ in content or readability (Flesch, 1948).

Each text was loaded on a web page. The background of the web page was a texture, whose principal color was light grey (#EAEBE6). A 14-pt Sans-serif Arial font , was used for all words except the title, which was 14-pt Arial in bold.

Questions

Since "the searching behavior supported by PDAs tends to be one in which the user seeks specific information" (Kim & Albers, 2001, p. 193), 20 clearly articulated questions requiring text answers were developed from the article. We ask the same questions for each text and compare the accuracy and performance time.

Key information

The key information is the right answer to the question; this information can be located in the beginning, middle, or end of the body of the text. Key information located at the beginning is the only condition in which the participants do not have to scroll multiple screens in order to view it. Therefore, information located at the beginning of the text might be easier to find than information in the middle or the end (see Kim & Albers, 2001).

2.6 Procedure

Participants met the experimenter individually in the cafeteria. At the beginning, they were given the PDA, were informed of the equipment and the procedure, and were asked to sign a consent form. The task consisted of answering 20 questions about a text appearing on their PDA by typing them in a specific web page. Participants were also informed that the PDA would record their performance time, starting from the appearance of each question and stopping when the answer was entered.

The web site appearing on the PDA with Internet *Explorer* started with a short questionnaire collecting demographic and other information (i.e., age, gender, education, computer and PDA user experience, habit of listening to music while working or studying). Afterwards, a second xhtml page appeared, composed of two frames: the article appeared in the superior frame, and a start link appeared in the

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syllables/total words) in a sample of 100 words. The Flesch index has been adapted to the Italian language in 1972 by Roberto Vacca and after that readapted by Vacca and Franchina (1986).
The following data show the scores for each text employed in our experiment:
Flesch-Vacca index (450 words) = 68 *Flesch-Vacca index* (550 words) = 69.2
Flesch-Vacca index (650 words) = 61.6 *Flesch-Vacca index* (800 words) = 67.6
According to the *Flesch-Vacca scale*, from 60 to 70 the text is defined as *easy*.

inferior frame. When the participants clicked on this link, the first question appeared in the inferior frame. For each remaining question, two new links appeared: answer and next.

Participants read the question and began searching through the article for the answer. When the participants found the answer, they clicked on the answer link. This opened a web page where they could enter their answer and their related confidence level on a Likert scale from 1 (“not at all”) to 5 (“absolutely self confident”). Once they closed this web page, the PDA stored their answers automatically. This process continued for all twenty questions; the experiment took about 35 to 45 minutes per participant, and the researcher was present for the entire experiment.

The questions were presented in random order. Participants answered the questions while listening to classical or Italian music or without listening to any music. For the first condition, music started when the participants opened the second xhtml page. At the end, participants filled in a final questionnaire to evaluate the accuracy of their answers and the principal disadvantages of the medium, layout, and text. Participants in the condition with music also indicated if the music helped or hindered their information search.

2.7 Measures

The results were measured in a number of ways: correct/incorrect answers; participants' confidence levels for each question, measured by a five-point Likert scale; and performance time in seconds.

The participants’ answers were recorded in an online database, and the accuracy of the answers was controlled by the researcher, who calculated the number of errors for each participant. The self-confidence level was automatically stored in the online database as a numeric value.

Concerning the first question, timing began once the participants click on the start link and ended when they clicked on the answer link. For all other questions, timing began once the participants clicked on the next link and ended when they clicked on the answer link. In this way, the performance time does not include the time employed by the participants to write the answer, which depends on the typing rate and does not have any relation with the searching task. Instead, the performance time is strongly influenced by the users’ scrolling behavior, reading rate, capacity of working memory, and information search strategy.

3. Results and Discussion

	Text length (in words):											
	450			550			650			800		
	wm[a]	cm[b]	Im[c]	wm	cm	Im	wm	cm	Im	wm	cm	Im
Average error	1	0.5	0.5	2	1.5	1.5	2	0.5	2	1.5	1.5	1.5
Average time	63	47	53	68	56	60	77	61	69	89	76	81
Standard deviation	24	18	21	25	22	23	24	22	24	27	23	24

Note. [a] without music. [b] with classical symphonic music. [c] with Italian music.

Table 1. Average error, Average time and Standard deviation across background conditions, without music (wm), with classical music (cm) and with Italian music (Im), for the different lengths of the text.

		Text length (in words):											
		450			550			650			800		
		wm[a]	cm[b]	Im[c]	wm	cm	Im	wm	cm	Im	wm	cm	Im
Location of the key information:	Beginning	62 (19)	36 (12)	47 (19)	54 (16)	51 (20)	63 (21)	59 (17)	54 (14)	58 (17)	74 (6)	59 (15)	78 (27)
	Middle	60 (22)	50 (17)	53 (19)	71 (27)	52 (17)	58 (22)	81 (24)	56 (21)	66 (15)	85 (22)	84 (24)	76 (16)
	End	77 (27)	62 (21)	65 (22)	83 (31)	81 (18)	66 (27)	91 (15)	77 (22)	90 (29)	117 (31)	85 (17)	95 (25)

Note. [a] without music. [b] with classical symphonic music. [c] with Italian music.

Table 2. Average time and (Standard deviation) across background conditions, without music (wm), with classical music (cm) and with Italian music (Im), for the different positions of the key information.

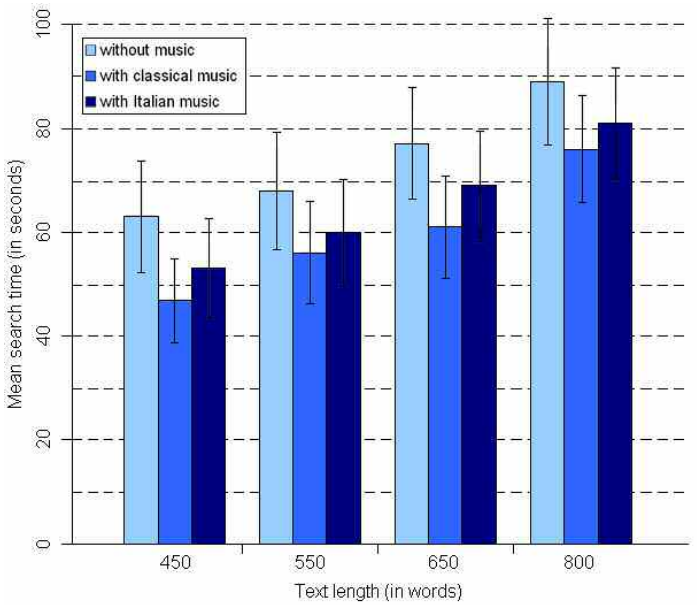

Figure 1. Mean search times across background conditions for the different lengths of the text.

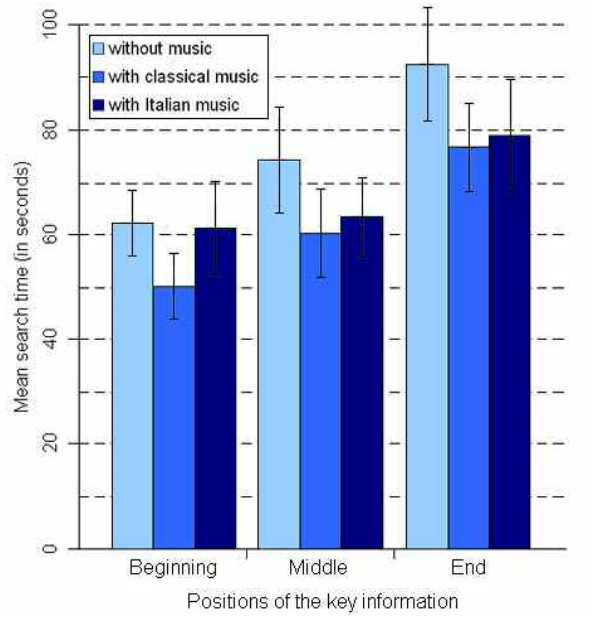

Figure 2. Mean search times across background conditions for the different positions of the key information.

3.1 Hypothesis 1

A multivariate analysis of variance (MANOVA) showed that the text length significantly influenced information searching ($F_{6,24} = 5.69$, $p < .05$). At a univariate level, accuracy was not influenced by the text length, whereas speed was significantly influenced; for all background conditions, when the text was rather long, the searching time increased (Figures 1 and 3). This suggests that the amount of text presented on the PDA affected the users' ability to retrieve information but did not prevent users from finding the right answers.

The background condition also significantly influenced performance ($F_{4,24} = 5.44$, $p < .05$). There were no significant interactions by MANOVA between the length of the text and the background condition.

We expected that participants should have more difficulty finding information in the middle and in the end of web pages than at the beginning. Time performance (Table 2) supported this assumption: a significant main effect of the location of the key information was found by repeated ANOVA measures across the three experimental conditions ($F_{2,42} = 89.72$, $p < .05$). Moreover, pair-wise comparisons reveal that searching time for information significantly increased when the key information was placed at the end of the web page rather than at the beginning or the middle ($p < .001$ for both).

Contrary to our expectations, the worst condition was searching for information without music and not with Italian music, in particular when the key information was placed at the middle and at the end of the page (Figure 2). No significant interaction effect was found between background condition and location of the key information.

3.2 Hypothesis 2

The level of accuracy was overall quite high (see Table 1), and the differences between the two conditions, with classical symphonic music and without music, were not significant by ANOVA. Thus, the second hypothesis is not supported.

3.3 Hypothesis 3

Results confirm our third hypothesis: classical symphonic music significantly improved the performance of the participants, reducing mean times to perform the tasks. Indeed, the differences in mean times between the two conditions, with classical symphonic music and without music, were significant by ANOVA ($F_{1,14} = 6.42$, $p < .05$). By suppressing meaningful irrelevant speech and isolating the subject from the surrounding world, classical symphonic music decreased distraction and enhanced attention, concentration, and arousal. According to the Yerkes-Dodson Law (Yerkes & Dodson, 1908), an optimal level of arousal causes an optimal level of performance.

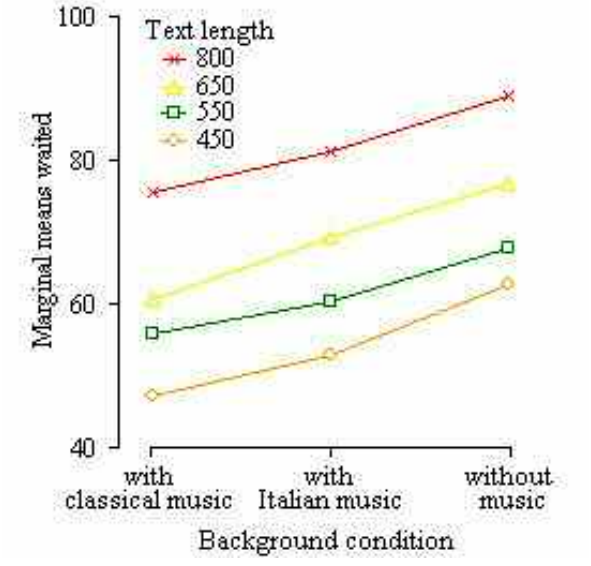

Figure 3. Marginal means of time.

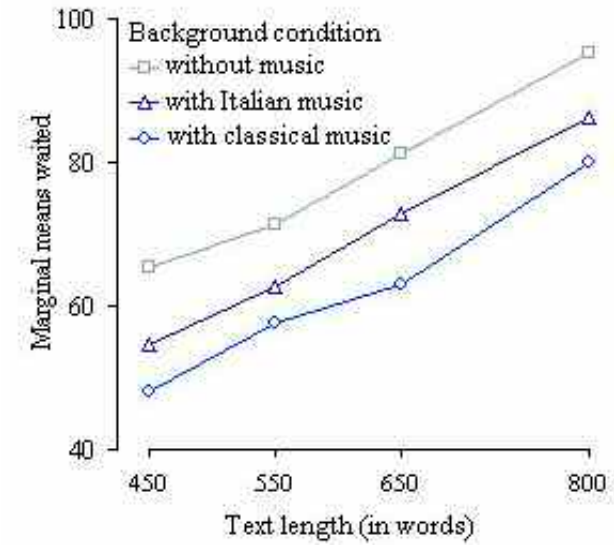

Figure 4. Marginal means of time.

3.4 Hypothesis 4

The fourth hypothesis was not supported by the results of the experiment. No significant differences by ANOVA were found for accuracy scores between the two conditions, with Italian music and without music; likewise, differences in error rate between the two conditions, with Italian music and with classical symphonic music, were not significant.

3.5 Hypothesis 5

Differences in mean times between the two conditions, with Italian music and without music, or with Italian music and with classical symphonic music, were not significant by ANOVA. Participants did not spend more time answering questions while listening to Italian music; while listening to either Italian or classical music, performance was better than without any music (Figures 1 and 4). Italian music reduced mean search times and improved performance, although not in a significant way.

This outcome contrasts with our initial hypothesis that the linguistic message present in the lyric would impair performance. A possible explanation is linked to the Yerkes-Dodson Law. Music increases the perceived social richness of the PDA and therefore the level of pleasure and arousal (Kallinen, 2004). Increased arousal corresponds with increased performance efficiency, which compensates for the impairment caused by the attenuated processing of the lyric.

Figure 4 shows that Italian music, which contains linguistic messages, is placed between classical symphonic music, which suppresses background conversation, and

without music, where background conversation is present. Perhaps, participants were distracted by the lyrics; however, this needs to be investigated in future studies, where also the effect of their level of familiarity with the songs is analyzed.

3.6 Likert Scale Point

Our study finds that the participants had good self evaluation ability: a high Likert score corresponds with a correct answer, while a low Likert score corresponds with a wrong answer. In the final questionnaire, almost all participants (about 92%) said that they were globally confident of their answers. Moreover, a high Likert score corresponds with key information placed at the beginning of the text, while a low Likert score corresponds with key information placed at the middle or end of the text. Indeed, a low Likert score often corresponds with longer performance time. This means that the subjects were less confident of the answer when they took more time to find it.

3.7 Final Questionnaire

In the final questionnaire, the participants considered the sensitivity of the stylus pen and the small dimension of PDA screen and keyboard as the principal disadvantages of the medium employed. The small character and page homogeneity were considered the principal disadvantages of the layout. The participants suggested that the main disadvantages in the text were the complexity of syntax and the lack of hierarchical layers, such as subtitles for each paragraph. A possible solution would be short and concise blocks of information, called *chunks*. The principal features of chunks are topic sentences placed in the opening position and the use of the upside-down pyramid method to give information (conclusion followed by supporting material). A web page organized in chunks is not syntactically complex and helps the reader access information quickly (Morkes & Nielsen, 1997); however, an excess of chunking could fragment the ideas expressed in the text and impair the user's ability to understand the information (Chu, 2001).

4. Conclusion

Some people in a crowded place, where the noise level is high, might think that listening to music improves concentration and helps us perform tasks more easily than intermittent background noises. Instead, in the present study, 45% of subjects believed

that music had compromised their performance; 35% said that music had no influence; and only 20% felt that music improved performance. The results of the experiment show that both classical symphonic music and Italian music improve searching ability. In particular, this study shows that participants who listened to classical symphonic music while searching for information on PDA in a noisy environment had a better performance.

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