Hiding to hedge against information overload: Diverging distraction effects due to task-irrelevant information from misleading associations

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Abstract. Many workspaces nowadays overload people with information – often with information that is irrelevant to the task at hand. Such information cannot only be distracting but additionally misleading, and can potentially impair the performance in relevant tasks. Here we set out to investigate how higher order cognition is influenced by such irrelevant or misleading information. Specifically we were interested in disentangling distraction effects due to task-irrelevant information from distraction effects due to misleading associations. To this end, we examined the solution rates for Remote Associates Test (RAT) items as a function of the presence of additional irrelevant or misleading word material, presented alongside the RAT items. Solving these kinds of word riddles is considered higher cognition as it is closely related to problem solving in real world scenarios. Additionally we manipulated the expectation of participants towards the nature of additional information across two experiments. In Experiment 1 participants believed that all additional words were irrelevant. In Experiment 2 they thought some of the information might be useful for their task. Alongside other manipulations we hereby ensured an attentional focus on the additional information in Experiment 2. Results showed, participants performed poorer in solving RAT items when irrelevant or misleading words were presented along with the RAT items compared to no additional presentation. Moreover misleading information was additionally interfering, but only if attentively processed. To avoid such distraction and misdirection, future personal information systems like the Semantic Desktop [1-2] can help by detecting and hiding temporarily irrelevant or misleading information.

Keywords: Mental fixation; problem solving; interference

1 Introduction

1.1 Distraction due to Information Overload

The digital age revolutionized our modern work environment. Pencils, paper and typing machines were replaced by keyboards and computers. Analogous stored information was transferred to digital file systems. Today you can hardly find a work space without a computer or other digital devices. The still ongoing progress in increasing memory capacity and computing power allows to store and manage huge amounts of relevant information at one small workplace, accessible at any time. Information can easily be shared among co-workers, processing paths can be shortened, time spared, work efficiency potentially increased. On the other hand the contemporaneous management of huge amounts of information can easily be overwhelming for people [3]. Often several files, systems or documents are opened at once and presented on a single computer screen. A sudden change of work task and context forces a worker to find different information and ignore still present but temporarily irrelevant contents from former tasks. Meanwhile incoming mails and system messages pop up and may lead to further distraction. Focusing on the tasks at hand can get exhausting. Workers have to free themselves of any irrelevant information, ignoring or suppressing it. Unfortunately work-related information cannot that easily be ignored, as it isn't always clear whether an information or content is relevant or not. Some information seem relevant at first glance but indeed are misleading for the actual task. In such cases misleading content may cause additional fixation, assumedly impeding job performance [4].

Here, we assumed that distraction due to knowingly task-irrelevant information can be distinguished from distraction due to misleading associations. Both forms of distraction can supposedly impair high cognition performance, though under attentive processing misleading associations are thought to lead to an additional detrimental fixation. In order to investigate such distraction effects, we ran two experiments in which participants were confronted with either irrelevant or misleading information while solving Remote-Associates Test items [5].

1.2 Remote-Associates Test

The Remote-Associates Test (RAT) was originally designed as a measure for creativity, or more precisely as a measure for individual differences in associative processing. Mednick [5] created several items, each consisting of three seemingly unrelated nouns. However, these nouns share exactly one other noun all three are related to. Participants' task is to find this target word (e.g. arm, coal, peach; solution: pit). Mednick [5] assumed that forming such remote associations is a requirement of creative thinking. The RAT soon became a measurement for several other constructs like problem solving, insight, memory, and brain storming abilities [6-9]. For example individuals with high solving rates in a RAT, also perform better in brainstorming groups [8]. All together the RAT can be regarded as a reliable measurement of higher cognition, having a close relatedness to creative problem solving [4, 9-10] in real world scenarios. Here, we used this established test to measure assumed detrimental distraction effects.

2 Experiment 1

Often our work at our digital workplace is interrupted by distracting information like system messages, advertisement, or incoming mails. Although surely distracting, we mostly know about the irrelevance of this information for our current work and can try to ignore and suppress it. Supposedly this may have costs for our performance in current tasks by depleting cognitive resources.

In a first experiment we wanted to investigate how performance in problem solving is influenced by the mere presentation of knowingly task-irrelevant information. Hence, participants were instructed that during the experiment all additionally presented word material would be irrelevant or even misleading for the task at hand and could be ignored. These instructions described the nature of the additional material correctly. It was indeed unrelated to all three RAT words and the solution, with some material being additionally misleading.

Though, the knowledge about the irrelevance of all additionally presented word material should lead to a general suppression or at least to a time consuming distraction. We assumed that such general suppression and distraction would deplete cognitive resources, impeding the performance in problem solving but irrespective of the nature of these words. Both the presentation of irrelevant and misleading information was assumed to equally result in worse performance compared to no presentation.

2.1 Methods

Participants. Forty-five undergraduate students (35 females; mean age = 23.8 years) at the University of Trier participated for course credit. Participants were tested in groups between six and twenty students at once.

Design. The study had a single factorial design with repeated measures (misleading vs. irrelevant vs. no distraction). Each participant had to solve twelve RAT items, four items in each of the three condition. The allocation of items to conditions was randomized across participants.

Material. This experiment was conducted with pen and paper. Each of the twelve RAT items was printed on one page. The order of items randomly varied across participants. A front page included instructions. The RAT items were chosen out of a list of German Compound Remote Associate word riddles published by Landmann et al. [11]. The list gave information about measured mean solution rates for each item. We selected twelve items that had a solution rate between 60 and 82.5 % after 60 seconds solution time. Besides we needed to choose items that had no obvious semantic relatedness to other items or even shared some words. Moreover additional word material was created. For each item two nouns were designed that had no relatedness to any of the nouns or the solution of that riddle. Two more nouns were designed to be related to one of the three nouns in that riddle but not to the solution, even leading on a wrong track. For example the noun *flu* would be an additional misleading word for the riddle of *virus, program,*

course, where *computer* is the solution. The word *flu* together with the noun *virus* can lead to an association towards diseases, which is misdirecting with the solution being *computer*. Each participant only had to solve each riddle ones. Which riddle was presented with irrelevant or misleading nouns or without anything was randomly assigned across participants. The additional words were printed right of the three nouns of given word riddle. Misleading additional nouns were presented on the same height as the related RAT noun.

Procedure. All participants took part on a voluntary basis during course. They were informed about the length of the experiment (around 15 minutes) and their task of solving twelve word riddles. After having decided to take part each participant got a stack of paper including all RAT items. The front page gave more detailed information about the task and the nature of the problem solving task. Participants were told, that for solving a word riddle they would have to find one noun that was related to all three centrally presented nouns. Participants furthermore were instructed that in some cases alongside the RAT items additionally nouns could be present. These words were said to be completely irrelevant and sometimes even misleading for the task of problem solving and could be ignored. When all participants had read the instruction and had no further questions, they all simultaneously started with the first RAT item. The experimenter started and ended all solving phases by oral instructions. Each 60s lasting solving phase was timed with a stopwatch.

2.2 Results

Direct comparisons of mean solving rates on an item based level between all three conditions showed significant differences between the *misleading* and *no distraction* condition, $t\,(11) = 2.727$, $p = .020$, $d = .576$, and between the *irrelevant* and *no distraction* condition, $t\,(11) = 2.599$, $p = .025$, $d = .556$ (see Fig.1). No significant difference could be found between the conditions *misleading* and *irrelevant*, $t < 1$.

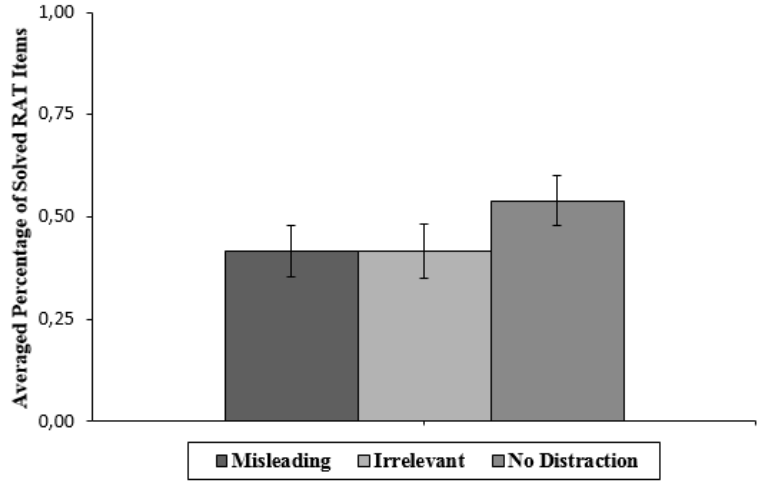

Fig. 1. Mean solving rates for RAT items as a function of condition in Experiment 1. Error bars represent standard errors of the mean.

2.3 Discussion

The presentation of additional word material led to poorer solving rates compared to no additional presentation. Here it didn't matter whether additional words were irrelevant or even misleading. The instruction that all additional information wouldn't be relevant for the given task, led participants to ignore and perhaps actively suppress these words. Trying to ignore or even generally suppressing the additional words had its cost by consuming cognitive resources and processing time, thereby distracting from solving the word riddles and impeding solving rates. Still, assumingly participants did not actively or attentively process the additional words. This experimental setting can be compared to work situations that confront us with knowingly irrelevant, distracting information like spam or advertisement. In those cases we can easily decide to ignore these contents. When prominently presented, these contents still lead to distraction, binding cognitive resources and time. The work on current tasks might still be impaired. But what if we are forced to attentively process information, e.g. to decide whether they are relevant for current tasks? In a second experiment we tried to address this issue.

3 Experiment 2

Much information, we have to deal with at work, cannot simply be ignored. First we have to make a decision about its relevance for our current task. For such decisions at least a fast and superficial processing of given information is necessary. However some information may not only be irrelevant but even misleading for the task at hand. In such cases an attentive focus on misleading information may cause a fixation on unhelpful

mental sets. This fixation could impede performance in problem solving as shown in some earlier work [4, 12]. In these studies distracting effects due to misleading associates could be found. Whenever misleading associates were presented on the same page alongside each of the three RAT words, the solution for the RAT item was more seldom found.

For our second experiment we created a new scenario, independent from our first experiment in order to specify the results reported above. Our aim was to compare distraction effects caused by attentively processed irrelevant and misleading information. We assumed that in line with existing research an attentive focus on misleading information causes a detrimental fixation. This should lead to an impeded problem solving ability compared to attentively processed irrelevant word material and compared to presentation of RAT items without additional words. Several changes were made in comparison to Experiment 1 in order to ensure an attentional focus on additional words. This time participants were instructed, that during the RAT solving phase the additionally presented words might be of help for solving the word riddles. They were not informed that in fact some of the additional material was irrelevant and some misleading but believed that all additionally presented words could be helpful for solving the tasks. Furthermore participants already learned the additional words at the beginning of the experiment, believing that they would be tested on them later on, which was not the case. Then, during the RAT solving phase the word stems of the additional words were already presented ten seconds before the related RAT items occurred. This gave participants time to remember and actively process the words. All changes in the experimental setting were made to increase the chances that participants would process the additional word material attentively.

Moreover we wanted to create an experimental setting that is closer to the daily work routine of a knowledge worker. For this purpose we transferred the experiment to a digital workspace, using and adapting a personal information management system. The RAT items had to be solved within an app on the Internet, while additional words were presented within a sidebar.

3.1 Methods

Participants. Forty undergraduate students (26 females; mean age = 24.6 years) at the University of Trier participated for course credit. Participants were tested individually in single laboratories.

Design. Similar to Experiment 1, Experiment 2 had a single factorial design with repeated measures (misleading vs. irrelevant vs. no distraction). In distinction to Experiment 1, this time this factor was partially varied between participants. Participants were divided in two groups. One group only dealt with misleading, the other with irrelevant information. Again, each participant had to solve twelve RAT items. This time six items were presented without additional words and six with either misleading (group 1) or irrelevant (group 2) words. The allocation of items to conditions was randomized across participants.

Material. The same RAT items and additional word material as in Experiment 1 were used again. In distinction to Experiment 1 this time the study was not conducted with pen and paper but at a digital workspace. Participants ran through the experiment at a computer, more specifically within an app on the Internet. There all instructions were given and the RAT items had to be solved. This time only the word stems (first three letters) of the additional word material were presented within a sidebar at the right side of the monitor. A preceding learning phase was added to the app. At the beginning of the experiment participants had to learn all misleading (group 1) or irrelevant (group 2) additional words. The words were sequentially presented for five seconds each. The learning phase consisted of two cycles.

Procedure. At arrival participants were seated in a small experimental room at a workplace with a computer, monitor, keyboard and computer mouse. There they found an already started experimental app. First they were asked for information about their age and gender before being instructed about the upcoming tasks. In the initial learning phase participants were instructed to learn and remember all following words in order to recall them later. Participants of group 1 had to learn all 24 misleading words. Participants of group 2 learned all 24 irrelevant words. The words were sequentially presented for five seconds each in a randomized order with 500ms blanks between them. After one cycle all words were presented a second time. Next, instructions for the RAT solving phase appeared. In contrast to Experiment 1, this time participants were instructed, that the additionally presented words might be of help for finding the solution of a word riddle.
Six out of twelve randomly chosen RAT items were presented without additional words. The other six items were preceded by the presentation of either two related misleading (group 1) or irrelevant (group 2) words in a sidebar on the right side of the screen. Only the first three letters of the additional words were presented. The presentation of the word stems started ten seconds before the RAT items occurred, to ensure their active processing, and lasted until the RAT item was solved or until the maximum time to solve it was reached. Per item participants could try to find a solution for a maximum of 120 seconds.

3.2 Results

Direct comparisons of mean solving rates on an item based level between all three conditions showed no significant differences between any pair of conditions. Both the comparisons between the *misleading* and *irrelevant* condition, t (11) = 1.367, p = .199, d = .377, and between the *misleading* and *no distraction* condition, t (11) = 1.335, p = .209, d = .319, only showed a tendency towards less correctly solved RAT items in the *misleading* condition (see Fig.2).

For examining a potential cost effect of attentively processing misleading words, we compared the *misleading* condition to a combination of the other two conditions. The direct comparison *misleading* vs. *irrelevant + no distraction* reached one-sided significance, t (11) = 2.012, p = .035, d = .433.

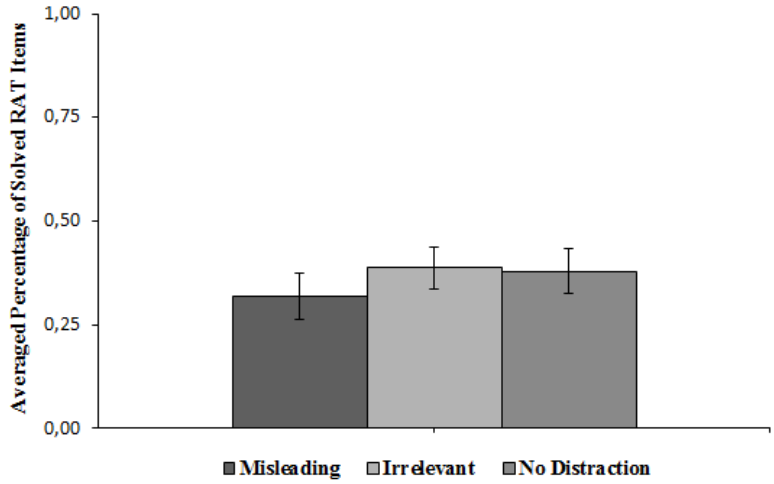

Fig. 2. Mean solving rates for RAT items as a function of condition in Experiment 2. Error bars represent standard errors of the mean.

3.3 Discussion

Participants solved less RAT items when they attentively processed related misleading words compared to conditions where items were presented alongside no or irrelevant words. These results are in line with past research that postulated a detrimental effect of fixation on misleading associates [4, 12]. Such fixation can impede the ability to generate appropriate solutions [10]. On the other side no cost effect for processing irrelevant information was present. The general distraction effect that was shown in Experiment 1 vanished in Experiment 2. In Experiment 2 participants solved as many RAT items when irrelevant nouns were presented as in trials where no additional words were shown. Due to the several procedural differences between Experiment 1 and 2, found differences in results are difficult to be attributed to one or another manipulation. Yet, the two experiments were conducted in order to describe different, independent scenarios. A direct comparison of performances across both experiments was not in the focus of this study. Nonetheless the most prominent reason for the missing cost effect of processing irrelevant information in Experiment 2 can be found in the procedural differences during the solving phase. In Experiment 1 all words were presented at once. Though, in Experiment 2 additional words were already presented ten seconds before the RAT items occurred. Already knowing and having processed the additional words, participants could easier concentrate on the RAT items. Still the fixation on misleading associates impeded the process of problem solving. Moreover in Experiment 2 participants had more time to solve the RAT items, reducing the need to suppress information, also if they were surely irrelevant for the task. Surely, the results of Experiment 2 are only a beginning of investigating potential distracting effects due to misleading information. Nonetheless they provide a novel view on the detrimental effects misleading

information can have in our daily information processing, especially in comparison to solely irrelevant information.

4 General Discussion

Across two experiments distraction effects caused by task-irrelevant and misleading information were examined. In Experiment 1 we copied an everyday scenario in which we know about the irrelevance of additionally occurring information. Here, a general distraction effect occurred. Participants less often found the solution to a problem solving task when they were additionally confronted with information that was knowingly irrelevant. Participants were equally distracted by different kinds of information, supposedly performing a general suppression of all additional contents. In a second experiment we copied another scenario of our daily work. One, in which we are confronted with information that may or may not be helpful for our current task and therefore has to be processed attentively. When participants were forced to actively process the additional content, it resulted in a cost effect of processing misleading information. A fixation on misleading associates impeded the ability to generate appropriate responses [4, 10, 12].

These results show that higher cognition is already negatively influenced by little amounts of distracting information. When this information is even misleading, a fixation on this actual irrelevant information further distracts us from working and thinking efficiently. Unfortunately we cannot fully shield us against all information that is surrounding us during daily work routines. Often we even have to actively detect the relevant information out of the available information. It is therefore important, to develop tools that support human cognition in the every growing information-rich working environment (see 4.1).

4.1 Implications

Our results should raise the awareness for possible cost effects of presenting too much and the wrong information during daily work routines. At times of information overload distraction effects like the ones shown in our studies are surely a common experience. Especially when we often have to switch between tasks, our digital workspace is overloaded with at least temporarily irrelevant information. An efficient information management has to be at hand. Personal information management systems like the Semantic Desktop [1-2] may be a partial solution to this problem. Such systems may support us in our information processing by adaptively detecting and temporarily hiding potentially distracting information. The more temporarily irrelevant or misleading contents are hidden on our desktop, the better we can process the relevant information. Development of such artificial systems should incorporate the knowledge cognitive psychology has gathered the last decades about forgetting and inhibition – as for example, pure decay functions are quite different from context-dependent forgetting. Future version of the Semantic desktop might actually use this knowledge and develop a digital forgetting/hiding that supports the functionality of human forgetting [13].

In any case, somehow the amount of information a worker is confronted with at once has to be reduced. Otherwise the feeling of information overload will increase as fast as the amount of stored information in the Internet.

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