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Abstract

It is often assumed that attention is automatically allocated to stimuli relevant to one's actual goals. However, the existing evidence for this idea is limited in several ways. We investigated whether words relevant to a person's current goal influence the orienting of attention even when an intention to attend to the goal-relevant stimuli is not present. In two experiments, participants performed a modified spatial cueing paradigm combined with a second task that induced a goal. The results of the experiments showed that the induced goal led to the orientation of attention to goal-relevant words in the spatial cueing task. This effect was not found for words semantically related to the goal-relevant words. The results provide evidence for motivational accounts of attention, which state that the automatic allocation of attention is guided by the current goals of a person.

Key words: spatial attention; attentional bias; goals; motivation; intentions

PsyclNFO classification: 2346, 2360

1. Introduction

Attention is regarded as a key mechanism to reduce the inputs in an environment full of stimuli, and to focus on relevant aspects of the environment (e.g., Yantis, 2000). The orienting of attention is herein a basic and fundamental process (Posner & Rothbart, 2005). As human behavior is largely dependent upon one's goals and motivations, it is essential that the orienting of attention is guided by one's goals and motivations to relevant stimuli. Imagine for instance that you enter a supermarket aiming to buy a newspaper and some chewing gum. There will be plenty of stimuli to which attention could be allocated. However, it is crucial for reaching your goal of buying these two items that your attention is oriented to them and, at first instance, to the location in the supermarket where you will find them.

1.1 Intended Orienting of Attention to Goal-Relevant Events

It is often assumed that pursuing a goal leads to the voluntary allocation of attention to goal-relevant stimuli and places (e.g., Yantis, 2000). For example, the goal of buying a newspaper is assumed to result in the voluntary allocation of attention to newspapers or places where newspapers are supposed to be located such as the newspaper corner in the supermarket. This form of attending to goal-relevant events is often described as "goal-directed" attention (Yantis, 2000). The term implies that voluntary attending to goal-relevant events serves the achievement of the pursued goal. In the example above, attending to the newspaper corner allows one to find and to buy a newspaper. Although often not acknowledged, this form of attending depends on the operation of two goals. First, the individual pursues the goal of buying a newspaper. This goal leads to a second, additional goal of attending to the newspaper corner. The second goal is obviously conditional on the first goal, but at the same time the second goal is the one responsible for the allocation of attention to the newspaper corner. In line with recent views of automaticity (Moors, 2007; Moors & De Houwer, 2006) we describe the second goal as a proximal goal in this situation, because it is directly related to the process under study (i.e., attending to the newspaper corner). The goal of buying the newspaper is the distal goal because it is not directly related to the allocation of attention to the newspaper corner. This form of attending to goal-relevant events can thus be described as (a) a goal-dependent process because its occurrence depends on the presence of a (distal) goal and (b) an intentional process because the allocation of attention to goal-relevant stimuli is caused by the second, proximal goal to engage in the process of attending to these stimuli (see Moors & De Houwer, 2006).

An important question is whether an intention to attend to goal-relevant events is necessary for the allocation of attention to these events. For example, can the orienting of attention to the newspaper corner in the supermarket be caused by the goal of wanting to buy a newspaper in the absence of an intention to attend to the newspaper corner? Several theoretical accounts suggest that the orienting of attention to goal-relevant events does not need to be caused by an intention to attend to these events (Ach, 1905; Lewin, 1926; Bruner, 1957; Neumann & Prinz, 1987; Moskowitz, Li, & Kirk, 2004). This point is of particular interest because intended orienting of attention is rather slow and less efficient than unintended attending (e.g., Horstmann, 2006). As effective goal pursuit should benefit from the fast and efficient allocation of attention to goal-relevant events, it would be adaptive when unintentional but goal-dependent attending is possible.

1.2 Evidence for the Unintended Attending to Motivationally and Goal-Relevant Events

Probably the most prominent evidence for this hypothesis comes from studies showing attentional orienting to certain classes of stimulus features such as novelty (Yantis & Jonides, 1984; Theeuwes, 2005), threat value (Öhman, Flykt, & Esteves, 2001; Koster, Crombez, Van Damme, Verschuere, & De Houwer, 2004), pain (Ecclestone & Crombez, 1999), high arousal (Vogt, De Houwer, Koster, Van Damme, & Crombez, 2008) or physical attractiveness (Maner et al., 2003). All of these stimulus features are seen as potentially important to our genetically determined, evolutionary evolved motives such as survival and reproduction. For example, new or threatening events present potential dangers for survival. Attractive persons of the opposite gender could offer possibilities for reproduction. High levels of arousal have been interpreted as indicative for such "relevant" events in general (Lang, Bradley, & Cuthbert, 1997; Vogt et al., 2008). Consequently, attending to these stimuli is often described as "motivated attending" (Lang, 1995). Furthermore, it is proposed that the allocation of attention to these kinds of events is hard-wired and does therefore not require an intention to attend to these events (e.g., Öhman et al., 2001). However, this probably inborn form of unintended attending to motivationally relevant events is limited to evolutionary motives. In addition, these studies never directly manipulated the underlying motives but relied only on theoretical assumptions to conclude that these motives underlie the effects. Therefore they provide no direct evidence that motives influence the allocation of attention in an unintentional way. In particular, they provide no evidence that also the temporary goals of an individual cause unintended attending.

More direct evidence for this hypothesis comes from the work by Folk and colleagues (Folk, Remington, & Johnston, 1992; Folk & Remington, 2008). These researchers aimed to show that the automatic orienting of attention to salient events such as colored or new cues is not stimulus-driven as proposed by other researchers (e.g., Yantis & Jonides, 1984) but is based on a top-down setting, namely the distal goals originating from the task set. Folk et al. (1992) showed that having the goal of localizing a colored target stimulus led to attentional biases towards colored cues briefly presented just before the target but not towards uncolored, abrupt onset cues. In contrast, having to detect an abrupt onset target led to the orienting of attention to abrupt onset cues but not to colored cues. This bias was found even when cues were not predictive for the location of the targets so that attending to the cues was not useful. Folk and colleagues (e.g., Folk et al., 1992) concluded that the task goal of detecting and thus localizing the targets resulted in the implementation of an attentional set for the defining features of the target stimuli. This set led to the attending to other stimuli carrying these features (i.e., the cues) even when an intention to attend to these other stimuli was not present.

The work by Folk and colleagues shows that relatively simple distal goals cause attending to goal-relevant events without depending on an intention to attend. However, it is unclear whether these effects can also be found with more complex goals that come closer to real-life goals. In order to investigate this question, the present research aimed to go beyond the existing studies in the following ways. First, we changed the nature and the number of the goal-relevant stimuli under study. Remember the example of wanting to buy a newspaper. This example shows that goal-relevant events are often not defined by one simple visual feature such as color but represent more complex stimuli. For example, wanting to buy a specific newspaper makes one most likely look for the name of this newspaper, and so for a word. Furthermore, it is unclear whether attention can be oriented to more than one goal-relevant stimulus. For instance, when the goal is to buy both a newspaper and chewing gum, is attention then automatically allocated to both items?

Second, we changed the nature of the distal goal under study. It is unclear whether distal goals other than those to localize stimuli are capable of influencing the allocation of spatial attention. It is evident that a localization goal makes space and the location of stimuli in space important. However, many of the actual goals of an individual will not be related to localizing. Therefore it is important to investigate to what extent the unintended allocation of spatial attention is also apparent when the distal goal is not to localize stimuli.

A third important issue concerns the manner in which goal-relevant stimuli are presented. In the design of Folk and colleagues (e.g., Folk et al., 1992), the goal-relevant stimuli under study (i.e., the cues) were presented extremely briefly before the actual targets and at the same location as the targets. It might be that unintended attending to goal-relevant cues is only possible when they share spatial and temporal characteristics with the targets. This would profoundly limit the scope of situations in which goals can evoke automatic attending. It would only occur in situations in which goal-relevant events are presented extremely briefly before one already expects and prepares for a goal-relevant event and when they appear in locations that are goal relevant. Therefore we investigated whether unintended attending can be found also for stimuli that are presented at other moments and at locations where targets never appear. Issues 2 and 3 are addressed in Experiment 2.

Finally, we were interested to see whether the allocation of attention generalizes to stimuli that were not goal relevant but semantically related to the goal-relevant events. Goal accounts assume that attention is guided by the semantic representation of a goal (e.g., Moskowitz et al., 2004). From this perspective one could expect that the allocation of attention makes no difference between goal-relevant and goal-related information. However, in the case of specific goals, such as the buying example above, the activated goal representation should be limited to truly goal-relevant information. Therefore, it should not include stimuli that are only semantically related to the goal-relevant events because related information is distracting and hinders effective goal pursuit (Veling & van Knippenberg, 2006, 2008; Parks-Stamm, Gollwitzer, & Oettingen, 2007). If such goal shielding effects extend to the attentional level, semantically related stimuli should receive less attention than goal-relevant stimuli.

1.3 Overview of the Present Experiments

We investigated the attentional processing of goal-relevant stimuli with a modified spatial cueing paradigm. This paradigm allows studying covert attentional orienting to peripheral cues and has been used especially to compare attentional processing of different stimulus categories such as emotional and neutral stimuli (e.g., Fox, Russo, Bowles, & Dutton, 2001). In this task, participants have to detect visual targets presented at the left or right side of a fixation cross. The target is preceded by a visual cue at the same location (validly cued trials) or opposite location (invalidly cued trials). Salient valid cues, such as emotional cues, typically lead to response time benefits (due to engagement of attention at the validly cued location), whereas salient invalid cues lead to response time costs (due to delayed disengagement of attention from the invalidly cued location), a difference referred to as cue validity effect. Studies using this paradigm have for instance shown that emotional cues lead to a larger cue validity effect than neutral cues and in particular to a difficulty to disengage attention from this information (Fox et al., 2001).

We combined the modified spatial cueing task with a task that induced a goal for which some of the cue stimuli were relevant. As cue stimuli and so as goal-relevant stimuli, we used words in order to have more complex stimuli which are not defined by only one visual feature. Two of these words were made goal relevant to have more than one goal-relevant stimulus. Using words also allowed us to use the synonyms of the goal-relevant words as cues to examine the attentional allocation to stimuli highly semantically related to the goal-relevant words.

2. Experiment 1

In Experiment 1, a goal was induced by asking participants to indicate (by pressing the spacebar) after each trial of the spatial cueing task whether one of two particular words (e.g., “field” or “ship”) was presented as cue in that trial (cf. Veling & van Knippenberg, 2006, 2008). Participants were told that they would be financially rewarded when they correctly indicated the presence of the two words. Consequently, these words can be regarded as goal relevant.

There are several reasons why increased attending to the location of the goal-relevant stimuli in this design can be regarded as evidence for unintended attending. First, the induced goal required participants to localize and to attend to all cue stimuli because participants had to check for each cue stimulus whether it was goal relevant. Hence, we expect the implemented goal to lead to an intention to attend to all cues. If we find that goal-relevant cues evoke a larger cue validity effect than other cues, this cannot be due to the intention to attend to all cues. Second, orienting more strongly to the location of the goal-relevant cues was not required for fulfilling the goal because the location of the goal-relevant cue stimulus was not relevant for the demanded reaction in the goal task. Therefore, participants should not have pursued an intention to give more attention to the location of the goal-relevant cues than to the location of the other cues.

2.1 Method

2.1.1 Participants

Thirty-four students (29 women) from different faculties at Ghent University participated. They were paid 7€ each. All participants had normal or corrected-to-normal vision and were naive as to the purpose of the experiment.

2.1.2 Apparatus and Materials

2.1.2.1 Words.

Eight words were selected as cues, and combined in four pairs of unrelated words. The four word pairs were (1) *stripe* (streep) and *work* (werk), (2) *line* (lijn) and *labour* (arbeid), (3) *field* (akker) and *boat* (boot), and (4) *land* (veld) and *ship* (schip). Each of the four pairs served one of the following functions: (1) goal-relevant cues, (2) goal-related cues, (3) control cues, and (4) control-related cues. The assignment of a function to a word pair was counterbalanced over participants. We used control cues because, in principle, it is possible that attention is oriented to goal-relevant words not because they are goal relevant but because they were mentioned explicitly in the instructions. To control for such pre-exposure effects, control words were also mentioned and had to be memorized during the instructions but they were not linked to a task that had to be performed during the experiment. In addition, we used the synonyms of these control words to have an appropriate control condition for the synonyms of the goal words.

The word pairs were constructed in the following manner. Neutral words were chosen from the database provided by Hermans and De Houwer (1994), and were completed with neutral words that matched these words concerning frequency as indicated by the WordGen tool (Duyck, Desmet, Verbeke, & Brysbaert, 2004) and word length. The chosen synonyms were checked via the Thesaurus synonym tool of Microsoft Office Word 2003 and with native speakers. As an additional control category, two words served as new words in each set, namely *newspaper* (krant) and *youth (*jeugd*)*. These words were chosen from the database by Hermans and De Houwer (1994) and matched the other words in frequency and word length. These words were neither semantically nor visually related to each other or any of the other words. In the practice block, five additional words were used.

2.1.2.2 Modified Spatial Cueing Task and Goal Task.

The experiment was programmed and presented using the INQUISIT Millisecond software package (Inquisit 2.0, 2005) on a Dell Dimension 5000 computer with an 85 Hz, 17-inch CRT monitor. All stimuli were presented against a black background. In the experiment, each trial of the spatial cueing task was followed by a trial of the goal task. On every trial of the spatial cueing task, a black fixation cross (5 mm high) placed in the center of a white rectangle (4.5 cm high x 5.5 cm wide) was presented in the middle of the screen (Figure 1). Along with this, two other white rectangles of the same size were presented, one to the left and one to the right of the middle rectangle. The middle of each of these two peripheral rectangles was 10 cm from the fixation cross. Cues and targets were presented within the peripheral rectangles. After 500 ms, a cue word appeared for the duration of 250 ms. Cue words were presented in Arial font size 16. Immediately after cue offset a target consisting of a black square (0.8 cm x 0.8 cm) was presented in the centre of one of the rectangles on the left or right side. Responses were made by pressing one of two keys (target left: "*q*"; target right: "*5*") with the left and right index finger on an AZERTY keyboard. A trial of this task ended after a response was registered or 1500 ms had elapsed since the onset of the target. In case an incorrect response was given, the word "ERROR" appeared for 200 ms in the middle of the screen.

One-thousand three-hundred ms after the end of each spatial cueing task trial, a red question mark (8 mm high) appeared in the middle of the screen that signaled the start of a goal task trial. The question mark indicated that participants should press the spacebar with both thumbs when the cue word in the spatial cueing task trial before had been one of the two goal-relevant words. The question mark was presented until a response was given or when 2000 ms had elapsed since the onset of the question mark. The next spatial cueing task trial started 600 ms after the end of the goal task trial.

Insert Fig. 1 at about here

In the spatial cueing task, cues correctly preceded target location (validly cued trials) on 50% of the trials. On the other 50% of the test trials, cue location was opposite to the target location (invalidly cued trials). Each cue word was presented equally often in both spatial locations. To control for responses to cues instead of targets, catch trials were presented. On these trials, a target did not follow the cue and no response was required. In order to ensure that participants maintained fixation at the middle of the screen, digit trials were presented. On these trials, the fixation cross was followed only by a randomly selected digit between 1 and 9 for a duration of 50 ms. Participants were instructed to report the digit aloud. Responses on digit trials were not recorded.

2.1.3 Procedure

2.1.3.1 Instructions and Practice Phase.

Participants were informed that a computer task would be presented, and gave a written informed consent. They were seated approximately 60 cm from a computer screen. All further instructions were presented on the computer screen. Participants were asked to respond as quickly and as accurately as possible to the location of the target by pressing the corresponding key. They were informed that a cue would precede the presentation of the target. Participants were instructed to maintain attention at the fixation cross.

Participants were further informed that after they responded to the target of the spatial cueing task, a red question mark would be presented in the middle of the screen. They were asked to press the spacebar with both thumbs if the cue had been one of the goal-relevant words. Participants were informed that this task did not require a fast reaction. In the practice phase, other cue words were used than in the test phase and only one of these cue word was goal relevant. The practice phase included 30 trials.

2.1.3.2 Test Phase.

Before the test phase, participants were presented with the two goal-relevant and the two control words. Participants were asked to memorize these words and to write them down after the words disappeared from the screen. The experimenter checked whether the correct words were written down. This was repeated until all words were memorized correctly. Hereafter, participants were told that the test phase would start. The goal-relevant and the control words were again shown with the information that these words would be used in the test phase. Participants were informed which of these four words were the two goal-relevant stimuli and would thus require an additional reaction when the question mark appeared. Moreover, participants were told that they would receive 3€ when they correctly indicated the presence of the two words in at least 85% of the trials for each of these words.

The test phase consisted of 192 trials. There were 160 test trials (32 trials for each of the five cue categories), 20 catch trials, and 12 digit trials. During the task, each word was presented 16 times. The order of trials was determined randomly and for each participant separately.

2.2 Results and Discussion

Trials with errors were removed from the data (0.04%). In line with previous studies using this modified version of the spatial cueing paradigm (Van Damme, Crombez, & Eccleston, 2004; Vogt et al., 2008), reaction times (RTs) shorter than 150 ms and longer than 750 ms were excluded from the analysis (2.73%). Means and standard deviations can be found in Table 1. During the test phase, participants never responded on the catch trials, suggesting that none of the cues was associated with a systematic response bias. Participants made errors on 3.98% of the trials in the goal task.

Insert Tab. 1 at about here

We performed a 5 (cue category: goal relevant, goal related, control, control related, new) x 2 (cue validity: valid, invalid) repeated measures analysis of variance (ANOVA) on the RTs. There was a significant effect of cue validity, $F(1, 33) = 22.96$, $p < .001$. Responses were significantly faster on validly cued trials (M = 428 ms, SD = 47 ms) than on invalidly cued trials (M = 448 ms; SD = 54 ms). The main effect of category was significant as well, $F(4, 30) = 8.82$, $p < .001$. RTs were slower after goal-relevant cues (M = 455 ms; SD = 61 ms) compared to all other cue categories (goal-related: M = 435 ms; SD = 49 ms; control: M = 438 ms; SD = 48 ms; control-related: M = 434 ms; SD = 50 ms; new: M = 429 ms; SD = 48 ms), $ts(33) > 4.14$, ps <

.001. Moreover, RTs were slower after control cues compared to new cues, $t(33) = 3.05$, $p < .006$.

Of particular importance to this study, the hypothesized interaction of cue validity and cue category was significant, $F(4, 30) = 3.58$, $p < .02$. To further explore the interaction, we calculated cue validity indices for each cue category by subtracting RTs on valid trials from RTs on invalid trials (see Table 1). Planned comparisons revealed that the cue validity index for goal-relevant cues was significantly larger than the cue validity index for control cues, $t(33) = 2.43$, $p < .03$. The cue validity index for goal-relevant cues was also significantly larger than the cue validity index for goal-related cues, $t(33) = 3.80$, $p < .002$, the cue validity index for control-related cues, $t(33) = 3.06$, $p < .005$, and the cue validity index for new cues, $t(33) = 2.91$, $p < .007$. The cue validity indices for control, goal-related, control-related and new cues did not significantly differ from each other, *t*s < 1.4, *ns*.

To further investigate specific effects on valid and invalid trials, planned comparisons were conducted on RTs on valid and invalid trials separately. On valid trials, participants responded as fast after goal-relevant cues than after all other cue categories, $t(33) < 1.63$, *ns*. Only RTs after new cues were significantly faster than RTs after goal-relevant cues, $t(33) = 2.67$, $p < .02$. The differences between most other cue categories on valid trials were not significant, $t(33) < 1.42$, *ns*. Only RTs after goal-related cues tended to be slower than RTs after new cues, $t(33) = 1.88$, $p = .069$.

On invalid trials, participants responded significantly slower after goal-relevant cues than after all other cue categories, *t*s(33) > 4.08, *p*s < .001, which is indicative of delayed disengagement of attention from goal-relevant cues. The differences between most other cue categories on invalid trials were not significant, *t*s(33) < 1.80. Only RTs after control cues were significantly slower than after new cues, $t(33) = 2.50$, $p < .02$.

Summing up, our analyses revealed that goal-relevant cues evoked larger cue validity effects in comparison to all other comparison categories. The analyses further showed that RTs on valid trials did not differ between goal-relevant cues and the categories of goal-related, control, and control-related cues, suggesting that goal-relevant cues did not engage attention. However, on invalid trials, RTs were significantly slower after goal-relevant cues compared to all other cue categories indicating delayed disengagement from goal-relevant cues. The effect on invalid trials also led to a main effect of type of cue when RTs were collapsed over valid and invalid trials. In sum, these results show that goal-relevant cues caused delayed disengagement of attention but, as expected, this effect was not present for goal-related words.

3. Experiment 2

In Experiment 2, a goal was no longer induced by asking participants to indicate the presence of particular cues in the spatial cueing task. Instead, after reacting to the target of the spatial cueing task, a single word appeared in the middle of the screen followed by a question mark that required participants to indicate (by pressing the spacebar) whether this word was one of the goal-relevant ones. To investigate unintended attentional processing of the goal-relevant stimuli, the words presented in the middle of the screen and the cue words were drawn from the same pool. As a result, the “true” goal-relevant words which required to press the spacebar were presented at other locations and other moments (i.e., in the middle of the screen after reacting to the target of the spatial cueing task) than the goal-relevant cue words (i.e., on the left or right side of the screen before the target of the spatial cueing task appeared) in the spatial cueing task. Thus, the second experiment went further than Experiment 1 because (a) it did not require participants to attend to the cues in the spatial cueing task in order to detect the goal-relevant words, (b) goal-relevant words in the goal task and goal-relevant cues in the spatial cueing task were presented at clearly other locations and at clearly other moments and (c) the location of the goal-relevant words in the goal task was fixed and the goal did therefore not require localization at all. Hence, increased attentional orienting to the location of the goal-relevant cues in the spatial cueing paradigm should not be caused by an intention to attend more strongly to the location of these cues.

3.1 Method

3.1.1 Participants

Thirty students (29 women) from different faculties at Ghent University participated. They were paid 4€ each. All participants had normal or corrected-to-normal vision and were naive as to the purpose of the experiment.

3.1.2 Apparatus and Materials

3.1.2.1 Words.

As cues we used the same pairs of words as in Experiment 1 except that we no longer used the new words. Four versions of this experiment were created and each of the four different word pairs served each cue function (goal-relevant, goal-related, control, control-related) once. Participants were randomly assigned to one of the four versions.

3.1.2.2 Modified Spatial Cueing Task and Goal Task.

The experiment was identical to Experiment 1 except for the following changes. Most importantly, the goal task was separated from the spatial cueing task. Six-hundred ms after responding to the target of the spatial cueing task, the goal task trial started with the appearance of a word presented in black on a white background in the middle of the screen for 250 ms (Figure 2). Hereafter, a red question mark (8 mm high) appeared in the middle of the screen, which indicated that participants had to press the spacebar when the preceding word in the middle of the screen had been a goal-relevant word. A trial of this task ended with a response or when 2000 ms had elapsed since the onset of the question mark. If a correct response was given after a goal-relevant word, the word “CORRECT” appeared for 200 ms in the middle of the screen. In case an incorrect response was given, the word “ERROR” appeared for 200 ms in the middle of the screen. The following spatial cueing task trial started 600 ms after the end of the goal task trial.

Insert Fig. 2 at about here

In this version, the three white rectangles were presented slightly closer to each other; the middle of each of the peripheral rectangles was now 9 cm from the fixation cross. Moreover, all words were presented in Arial Black, font size 20. Finally, in this version cues correctly predicted the target location (validly cued trials) on 75% of the trials. On the remaining 25% of the test trials, cue location did not predict target location (invalidly cued trials).

3.1.3 Procedure

The procedure remained the same as in Experiment 1 except for the following changes. Participants were informed that after they responded to the target of the spatial cueing task, a word would be presented in the middle of the screen. They were asked to press the spacebar with both thumbs when this word had been one of the two goal-relevant words. In the practice phase, other words were used and only one of the words was goal relevant. Participants practiced the task during 22 trials. The test phase consisted of 140 trials of the spatial cueing task and 140 trials of the goal task. For the spatial cueing task these were 128 test trials (32 trials for each of the four cue categories), eight catch trials, and four digit trials. During this task, each word was presented 16 times. For the goal task these were 140 test trials, 35 trials for each word category. Hence during the goal task, each word was presented 17 to 18 times. The order of trials for both tasks was determined randomly and for each participant separately. The order of the spatial cueing task trials and goal task trials was selected independently of each other. In this experiment, participants were told that they would win 5 Euro Cents every time they pressed the spacebar after one of the goal-relevant words.

3.2 Results and Discussion

Trials with errors were removed from the data (0.09%). RTs shorter than 150 ms and longer than 750 ms were excluded from the analysis (2.1%). Means and standard deviations can be found in Table 2. Participants responded on none of the catch trials during the test phase, suggesting that none of the cues was associated with a systematic response bias. Participants made errors on 2.36% of the goal task trials.

We performed a 4 (cue category: goal relevant, goal related, control, control related) x 2 (cue validity: valid, invalid) repeated measures analysis of variance (ANOVA) on the RTs. We found a significant effect of cue validity, $F(1, 29) = 23.03$, $p < .001$, with faster reactions on validly cued trials (M = 405 ms; SD = 44 ms) compared to invalidly cued trials (M = 438 ms; SD = 55 ms). The main effect of category reached significance, $F(3, 27) = 7.09$, $p < .002$. RTs were slower after goal-relevant cues (M = 434 ms; SD = 49 ms) compared to all other cue categories (goal-related: M = 415 ms; SD = 52 ms; control: M = 424 ms; SD = 46 ms; control-related: M = 413 ms; SD = 48 ms), $ts(29) > 2.37$, $ps < .03$. Additionally, RTs were slower after control cues compared to goal-related cues, $t(29) = 2.20$, $p < .04$, and after control cues compared to control-related cues, $t(29) = 3.09$, $p < .005$.

Insert Tab. 2 at about here

Most importantly, the hypothesized interaction of cue validity and cue category was significant, $F(3, 27) = 6.76$, $p < .003$. Planned comparisons revealed that the cue validity index for goal-relevant cues was significantly larger than the cue validity index for control cues, $t(29) = 2.78$, $p < .02$. The cue validity index for goal-relevant cues was also significantly larger than the cue validity index for goal-related cues, $t(29) = 4.38$, $p < .001$, and the cue validity index for control-related cues, $t(29) = 2.59$, $p < .02$. The cue validity indices for control, goal-related and control-related cues did not differ significantly from each other, ts < 1.6, *ns*.

Planned comparisons revealed that on valid trials, participants responded as fast after goal-relevant cues than after all other cue categories, ts(29) < 1, *ns*. Only the difference to the control-related cue category approached significance, $t(29) = 1.88$, $p = .071$. The differences between the other cue categories on valid trials were not significant, ts(29) < 1.65.

Analyses on invalid trials showed that participants responded significantly slower after goal-relevant cues than after all other cue categories, ts(29) > 3.37, ps < .003, indicating delayed disengagement of attention from goal-relevant cues. The differences between the other cue categories on invalid trials were not significant, except that RTs after goal-related cues were significantly faster than RTs after control cues, $t(29) = 2.11$, $p < .05$. The difference between control cues and control-related cues approached significance, $t(29) = 1.92$, $p = .064$.

In sum, the results of the second experiment replicated the results of the first experiment. Goal-relevant cues evoked larger cue validity effects than all other comparison categories. Further, responses on valid trials did not differ between goal-relevant cues and the other cue categories indicating that goal-relevant cues did not engage attention. In contrast, RTs were significantly slower after goal-relevant cues compared to all other cue categories on invalid trials which is indicative of delayed disengagement of attention from goal-relevant cues. Thus, also in Experiment 2, the main effect of type of cue was caused by slow RTs on invalid trials after goal-relevant cues. In conclusion, goal-relevant cues led to delayed disengagement of attention but attending to goal-related words did not differ from attending to control words and control-related words.[1]

4. General Discussion

The main aim of our experiments was to examine whether larger cue validity effects would be evoked by goal-relevant words compared to control words when there was an intention to detect goal-relevant words but no intention to give more attention to the location of these words than to the location of control words (Experiment 1) or when there was no intention at all to attend more strongly to these words in the spatial cueing task (Experiment 2). Moreover, we investigated the attentional processing of words semantically related to the goal-relevant words. The results of both experiments indicated that goal-relevant words delayed disengagement of attention (as inferred from responses to invalidly cued targets) more than other types of stimuli. This effect held even when the spatial cueing task and the goal task were spatially and temporarily separated which also made the preferential attentional processing of goal-relevant words in the spatial cueing task not instrumental at all for the goal task. We found no evidence that attending to the goal-related words differed from attending to the control categories.

The present evidence suggests that not only stimuli relevant to our evolutionary motives such as survival and reproduction influence the allocation of spatial attention but also stimuli relevant to the temporary goals of an individual. As such, the results of our experiments extend the evidence by Folk and colleagues (e.g., 1992, 2008) by showing that the unintended effects of goals on attention are not limited to goal-relevant stimuli defined by only one simple visual feature but extend to more complex stimuli such as words. In addition, our experiments demonstrated that when the distal goal entails two different stimuli, attention is automatically allocated to both stimuli. Moreover, Experiment 2 showed that this effect does not depend on a localizing goal or does not only occur when goal-relevant cues are presented at almost the same time and the same location as the true goal-relevant events. Finally, in line with recent goal accounts (Veling & van Knippenberg, 2006, 2008; Parks-Stamm et al., 2007) we found that this effect is restricted to goal-relevant stimuli and does not extend to words that are semantically related to the goal-relevant words but that are not goal relevant themselves.

The fact that goal-relevant stimuli primarily slowed down responding on invalid trials suggests that the observed larger cue validity effects for goal-relevant stimuli were due mainly to difficulties to disengage attention from goal-relevant words. This is in line with studies showing that attention to threatening (Fox et al., 2001; Yiend & Mathews, 2001) or high arousing events (Vogt et al., 2008) is best characterized as a difficulty to disengage from this information. From a functional perspective, it makes sense that motivationally and goal-relevant stimuli lead to a difficulty with attentional disengagement because holding of attention at a stimulus allows the organism to further process this stimulus. However, future research should investigate whether paradigms that are more appropriate to investigate attentional capture can find automatic attending to goal-relevant stimuli also at even earlier levels of attentional processing.

What is the mechanism allowing the automatic allocation of attention to goal-relevant events? Goal accounts propose that goals render the relevant goal concept highly accessible which in turn directs attention (Bruner, 1957; Moskowitz et al., 2004). Current views of the influence of working memory on attentional processing support this assumption (Desimone & Duncan, 1995; Downing, 2000; Pratt & Hommel, 2003; Soto, Hodsoll, Rotshtein, & Humphreys, 2008). Although it was underlined for a long time that attention selects the stimuli from the environment that enter working memory, these current views propose that the contents of working memory also influence the attentional selection process. Indeed, it has now been shown that highly activated representations of objects in working memory direct visual attention automatically to matching objects in the environment (for an overview see Soto et al., 2008).

However, the present findings suggest that the guidance of attention by the mental representation of a (specific) goal is different than the guidance by non-goal representations (see Förster, Liberman, & Friedman, 2007, for a recent discussion of the differences between goal and non-goal representations). The activation of non-goal representations also leads to the allocation of attention to stimuli that are semantically or associatively related to the activated representations in working memory (Stolz, 1996; see also Moores, Laita, & Chelazzi, 2003; Meyer, Belke, Telling, & Humphreys, 2007). For instance, in the study by Stolz (1996) words were presented at the fixation point of a spatial cueing task and participants were instructed to read these words. Words that were semantically related or unrelated to the word at the fixation point were used as spatial cues. Stolz (1996) found that semantically related words led to delayed disengagement of attention in comparison to semantically unrelated words. In contrast, the results of our study showed that attention is not more strongly oriented to stimuli that are semantically related to the goal-relevant information. This is in line with studies showing that the mental representations of specific goals are limited to true goal-relevant information. Hence, they do not include stimuli that are semantically related to a goal in order to shield the goal against goal-irrelevant distractors (Veling & van Knippenberg, 2006, 2008; Parks-Stamm et al., 2007). We can thus conclude that the content of an activated representation and consequently the attentional allocation to representation-related information differ depending on whether a goal or a non-goal representation is activated.

However, goal-related information does not necessarily need to be excluded from a goal representation because such information could also be useful during goal pursuit. For instance, when looking for a particular newspaper, it might be helpful that attention is allocated to other newspapers because they might allow finding the newspaper one is looking for. This example suggests that whether goal-related information is activated or not in the goal representation - and thus its influence on attention - depends on the functionality of this information for goal pursuit.

Moreover, attention might only be exclusively allocated to truly goal-relevant information when individuals have learned through experience with a goal to inhibit distracting and irrelevant information. Work by Shah (Shah, Friedman, & Kruglanski, 2002) suggests for instance that automatic goal-shielding effects rely on the over-learned and therefore automatic inhibition of distracting information when a particular goal is activated. In our experiment, the extensive experience with the goal stimuli and the distracting goal-related stimuli could have served as a learning phase.[2]

In future research, variations of the present paradigm and design might be helpful to further explore the mechanisms underlying the present findings. First, in the present experiments, only one cue was presented on each trial. As a result, shifts in attention might have been determined primarily by the mere onset of the single cue, leaving little room for additional effects of the meaning of a cue on early attentional processes. It would thus be worthwhile to examine the effects of goal-relevant and goal-related stimuli in a task where two cues are presented simultaneously (e.g., the dot probe paradigm, MacLeod, Mathews, & Tata, 1986; see also Footnote 1). It would be particularly interesting to see whether attention is allocated also to goal-related stimuli when they are presented in competition with control words because goal-related words might have an influence on early attentional processes (but see Stolz, 1996).

Second, in the present study, goal-relatedness was operationalized as semantic relatedness within the same modality (i.e., semantically related written words). Future studies could investigate the effects of other forms of relatedness such as stimuli with identical meaning that are presented in different modalities (e.g., the same word spoken and written). If the effect of goal-relevant words on attention is mediated by an abstract semantic representation of those words, attention should be allocated to goal-related words that have the same semantic meaning as the goal-relevant words but that are presented in a different modality. It is, however, also possible that attentional orienting is guided by a low-level visual representation of the goal-relevant words (e.g., the visual form of the letters of the words). This could explain why goal-related words did not attract attention in our study because they did not share the visual features of the goal-relevant words. In this case, attentional guidance should also be modality specific. The fact that we found a difference between goal-relevant and goal-related stimuli especially near the end of the experiment (see Footnote 2) is relevant in this context. It suggests that guidance by a specific visual representation evolved during the task as a consequence of the specific design of the goal task. For instance, it is possible that participants initially distinguished between goal-relevant and other stimuli on the basis of the (broad) semantic meaning of the goal-relevant words in the goal task (resulting in the allocation of attention also to goal-related words). Afterwards, however, they learned to make the distinction on the basis of low level visual features (in which case goal-related words would no longer attract attention). Hence, when a goal is new or goal-relevant stimuli cannot easily be distinguished from other stimuli on the basis of low level features, guidance might be based on (broad) semantic stimulus representations in working memory and also goal-related stimuli might draw attention (cf. Woodman, Luck, & Schall, 2007). These issues can be addressed in future research.

Our conclusions need to be qualified to some extent. First, because the majority of our participants were women, one should be careful in generalizing our conclusions to men. However, we are not aware of any theoretical arguments suggesting that gender influences either the allocation of spatial attention or the pursuit of a goal such as the one used in our study. Second, in both experiments participants were given the goal of winning money by correctly reacting to goal-relevant words in the goal task. This was done in order to give participants a goal that is attractive and motivating. One could argue that this leaves open whether the effect for goal-relevant words is driven by their goal relevance or merely by the fact that goal-relevant words were related to a monetary reward. However, an additional experiment (see Footnote 1) revealed similar results even when monetary rewards were not used. Third, we implemented a cue exposure time of 250 ms which might have allowed eye movements to take place. Future research should therefore investigate the allocation of attention to goal-relevant events that are presented even more briefly. Finally, in Experiment 2, we used a cue validity ratio of 75%. One could thus argue that participants were given an incentive to attend to cues in general. Although this cannot explain the main finding of the experiment (i.e., attention is primarily allocated to goal-relevant cues), one could argue that Experiment 2 leaves open the question whether unintended attending to goal-relevant cues occurs also when attending to (goal-relevant or other) cues is not instrumental. More recent studies that were conducted in our lab suggest an affirmative answer to this question. For instance, in one of these studies (see Footnote 1), attention was allocated to goal-relevant cues that were presented simultaneously with goal-unrelated control stimuli even though the nature of the cues was unrelated to the subsequent position of the target.

Coming to the broader implications, our results underline the role of goals in the automatic orienting of attention. By this, our findings support old and recent models of attention and motivation. First, our findings are in line with Allport's influential proposal (Allport, 1989) that the function of attention is the selection of action- and goal-relevant information (see also Neumann & Prinz, 1987; Hommel, in press) that went against the view that attention is an expression of limited cognitive resources (e.g., Kahneman, 1973). Second, various accounts on motivation and goal pursuit assume that goals influence early cognitive processing and in particular the automatic allocation of attention (Lewin, 1926; Bruner, 1957; Moskowitz et al., 2004) in order to support successful goal pursuit.

In conclusion, the present findings show that the implementation of a specific goal leads to the automatic orienting of attention to goal-relevant words but not to merely goal-related words. Future research is needed to further examine the influence of goals on automatic attending, taking into account the specificity of a goal, the experience with it, and the functionality of goal-related stimuli in goal pursuit.

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Footnotes

[1]We replicated the present results with a modified version of the procedure used in Experiment 2 (*N* = 16; 3 men). The following changes were implemented. First, two cues were presented simultaneously in each trial of the cueing task, one above and one below the fixation cross. One of the cues was always a goal-relevant stimulus while the other cue was always a (goal-unrelated) control word. Second, the cueing and the goal task consisted of 144 trials. Third, because two cue words were presented, the SOA was raised to 350 ms. Fourth, the position of the target could not be predicted above chance on the basis of the position of the goal-relevant (or control) cue. Hence, attending to the cues was not instrumental for performing the cueing task. Finally, participants did not receive a reward for correctly indicating the presence of goal-relevant words in the goal task. Results showed that participants were significantly faster to react to targets appearing on the former location of goal-relevant cues (*M* = 456 ms; *SD* = 43 ms) than to targets appearing on the former location of a control cue (*M* = 470 ms; *SD* = 52 ms), $t(15) = 2.78$, $p < .02$, indicating that attention was allocated to goal-relevant cues also in this experiment.

[2]Note that our data in fact support this assumption. When we look at the first and the last quarter of Experiment 2 separately, then the difference between the cue validity index for goal-relevant cues (*M* = 46 ms; *SD* = 85 ms) does not differ significantly from the cue validity index for goal-related cues (*M* = 37 ms; *SD* = 72 ms) in the first quarter, $t < 1$. However, in the last quarter, the cue validity index for goal-relevant cues (*M* = 57 ms; *SD* = 53 ms) is significantly larger than cue validity index for goal-related cues (*M* = 20 ms; *SD* = 54 ms), $t(28) = 3.18$, $p < .005$.

Table 1

Mean Reaction Times, Standard Deviations, and Cue Validity Indices (in ms) as a Function of Cue Category and Cue Validity in Experiment 1.

	Valid		Invalid		Cue validity indices	
Cue category	*M*	*SD*	*M*	*M*	*M*	*SD*
Goal-relevant words	435	59	474	70	39	44
Goal-related words	428	47	441	56	13	32
Control words	428	47	448	52	20	26
Control-related words	427	51	442	56	15	41
New words	422	47	436	54	14	32

Note. Cue validity indices were calculated by subtracting reaction times on valid trials from reactions times on invalid trials.

Table 2

Mean Reaction Times, Standard Deviations, and Cue Validity Indices (in ms) as a Function of Cue Category and Cue Validity in Experiment 2.

	Valid		Invalid		Cue validity indices	
Cue category	*M*	*SD*	*M*	*SD*	*M*	*SD*
Goal-relevant words	408	44	459	62	51	44
Goal-related words	405	47	425	66	20	46
Control words	408	45	441	56	33	43
Control-related words	400	51	427	59	27	53

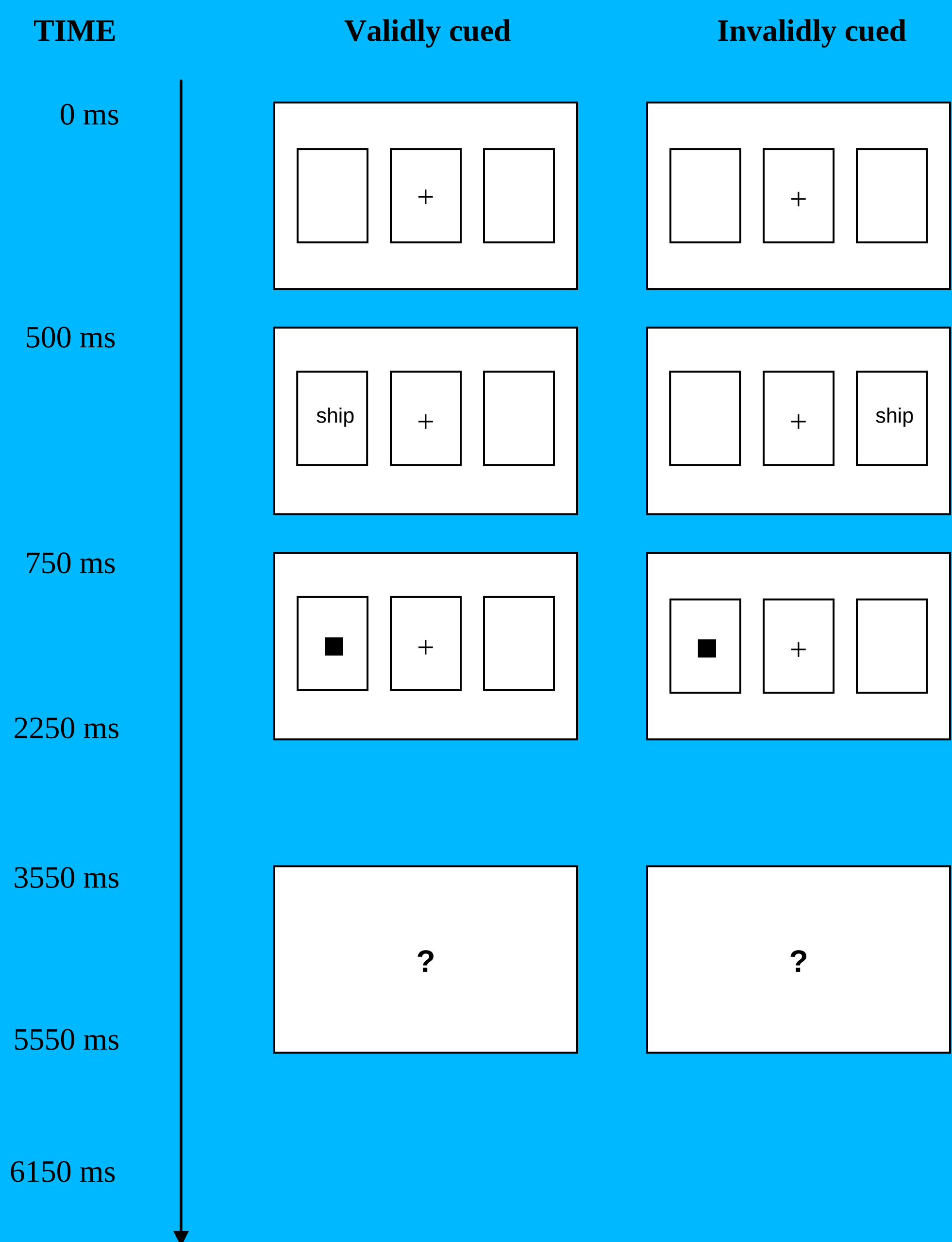
Note. Cue validity indices were calculated by subtracting reaction times on valid trials from reactions times on invalid trials.

Figure captions

Figure 1. Schematic overview of two example trials of the combined spatial cueing and goal task in Experiment 1. The first three boxes depict the spatial cueing task in which the presentation of a cue word was followed by a target (black square) which had to be localized. The last box depicts the goal task in which participants had to react to the question mark by pressing the spacebar when the cue had been one of the two goal-relevant words. The left side illustrates a validly cued trial of the spatial cueing task, the right side an invalidly cued trial of this task.

Figure 2. Schematic overview of two example trials of the combined spatial cueing and goal task in Experiment 2. The first three boxes depict the spatial cueing task in which the presentation of a cue word was followed by a target (black square) which had to be localized. The last two boxes display the goal task in which the presentation of a single word was followed by the appearance of a question mark. Participants had to react to the question mark by pressing the spacebar when the single word presented in the middle of the screen had been one of the two goal-relevant words. The left side illustrates a validly cued trial of the spatial cueing task, the right side an invalidly cued trial of this task.

Figure 1.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Invalidly cued
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2250 ms
3550 ms
5550 ms
6150 ms
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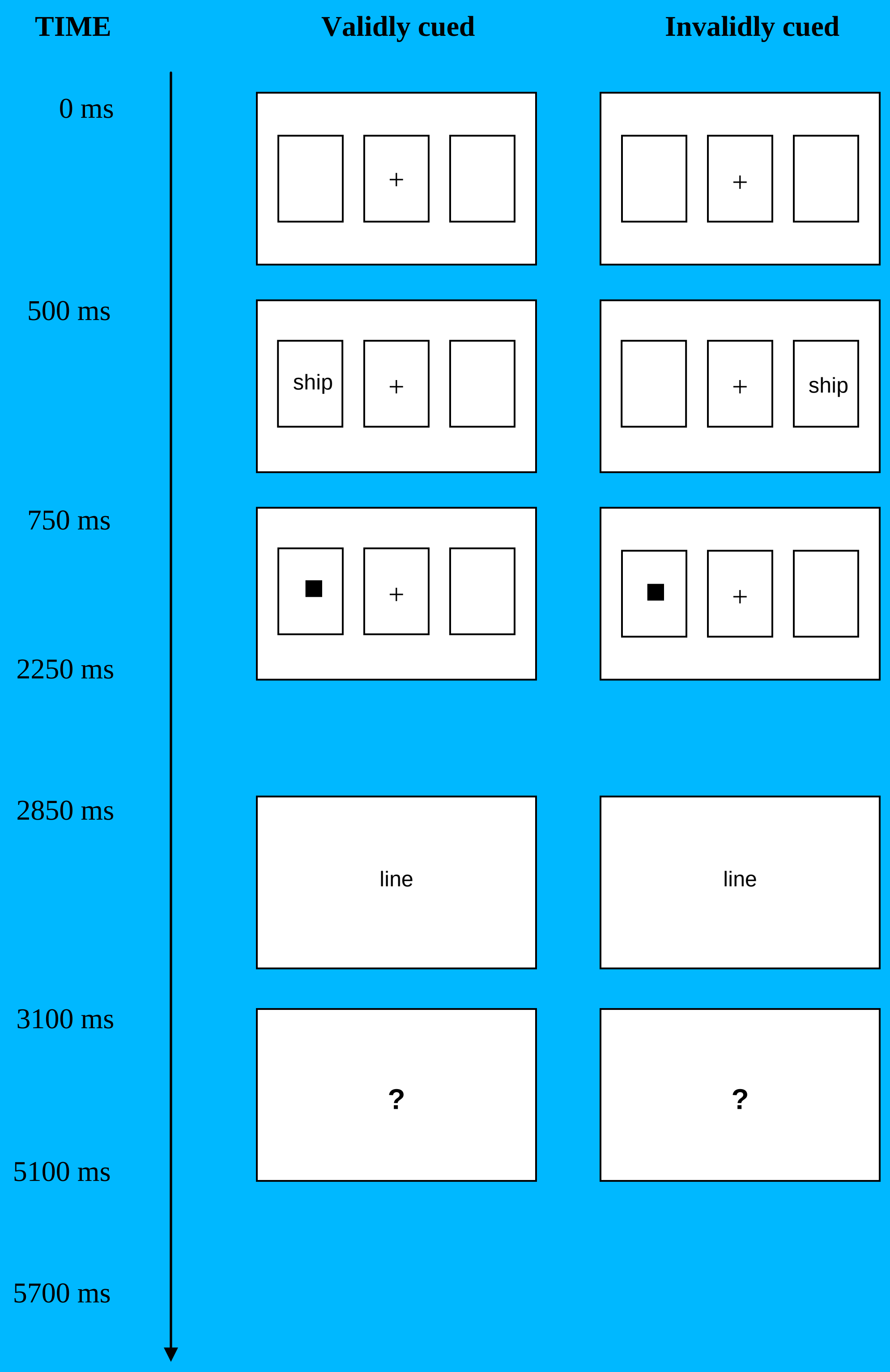
Figure 2.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0 ms
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2250 ms
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