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# When Time Flies: How Abstract and Concrete Mental Construal Affect the Perception of Time

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Time is experienced as passing more quickly the more changes happen in a situation. The present research tested the idea that time perception depends on the level of construal of the situation. Building on previous research showing that concrete rather than abstract mental construal causes people to perceive more variations in a given situation, we found in 3 studies that participants in a concrete mind-set experienced time as passing more quickly than participants in an abstract mind-set. In 2 further studies we demonstrated that the level on which actual changes happen in a given situation moderated this effect: Changes in high-level aspects mainly affected time estimation of participants primed with an abstract mind-set, whereas changes in low-level aspects affected time estimation of participants primed with a concrete mind-set.

*Keywords:* construal level, mind-set, time perception, time estimation, variations

The experience of time is a highly subjective phenomenon. The same situation can be perceived to pass very quickly or very slowly, depending on diverse situational factors, such as the attractiveness or the richness of a situation (e.g., Ahn, Liu, & Soman, 2009; Vohs & Schmeichel, 2003; Zakay & Block, 1996, 2004), the presence of music (e.g., Droit-Volet, Bigand, Ramos, & Bueno, 2010), stress (e.g., Meck, 1983), arousal (e.g., Drew, Fairhust, Malapani, Horvitz, & Balsam, 2003), or medication (e.g., Maricq & Church, 1983). The present research adds to this research by examining whether abstract and concrete mental construal influence the experience of time and whether the level on which changes happen in a situation moderates this effect.

Internal clock models (e.g., Gibbon, 1977; Gibbon, Church, & Meck, 1984) and their extensions (i.e., attentional gate models; e.g., Thomas & Weaver, 1975; Zakay & Block, 1995, 1997) explain variations in temporal perceptions in terms of attentional processes. These models assume that an internal clock emits and accumulates temporal pulses over an elapsed time. Subjective time perception depends on the number of accumulated pulses. The more pulses that are accumulated, the longer a situation appears to be. The amount of attention paid to the processing of time, however, may affect the experience of time. Attentional resources are divided between stimulus information and temporal information (i.e., the internal clock). When attention is distracted from the temporal information, fewer temporal pulses are accumulated, and a situation is perceived as shorter (Droit-Volet et al., 2010; Hicks, Miller, Gaes, & Bierman, 1977; Thomas & Weaver, 1975; Zakay, 1989). Consequently, the more changes that happen in a situation, the shorter a situation should appear because more attention is distracted from time (Block, 1989, 1990; Block, Hancock, & Zakay, 2010; Block & Reed, 1978; Block & Zakay, 1997, 2004). In other words, "time flies" when a lot happens that diverts attention away from time.[1]

Experiments that varied processing difficulty (Buchwald & Blatt, 1974; Hanley & Morris, 1982), distraction (Block, George, & Reed, 1980; Block et al., 2010; Block & Zakay, 2008), or changes in the situation in which time is judged (Ahn et al., 2009; Avni-Babad & Ritov, 2003) have consistently demonstrated that rich experiences are perceived as subjectively shorter. In a study by Ahn et al. (2009, Experiment 2), for instance, participants watched a show of five slides that were presented five times each. The slides were presented either in blocks each consisting of five presentations of the same slide or in a fixed quasirandom order. The latter condition provided participants with a situation with a lot of stimulus variation, whereas the former provided only a few changes. Accordingly, participants estimated the randomized slide presentation as being subjectively shorter.

Although changes can happen objectively in a given situation, the degree of variation in a situation is often subjectively con-

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[1] Several moderators of this effect have been investigated, such as expectation of change (e.g., Ahrens & Sahani, 2011; Fortin, 2003), speed of movement (Brown, 1995), and reinforcements (Killeen & Fetterman, 1988). These moderators are beyond the scope of this article and will not be discussed further. In contrast to *perceived progression* of time, the temporal intervals are *represented* as longer when a large number of changes occur (e.g., Fraisse, 1963; Kanai, Paffen, Hogendoorn, & Verstraten, 2006). We come back to this important distinction in the General Discussion section.

strued. That is, the very same situation may be perceived as either diverse or homogeneous, which, in turn, may influence the experience of time. The level on which individuals mentally construe a situation (Liberman & Trope, 2008; Trope & Liberman, 2003, 2010; Vallacher & Wegner, 1987, 1989) is relevant here, as high-level construals are less diverse, and include fewer details and less contextual information than low-level construals. More specifically, high-level construals are abstract mental representations that extract the essential, core aspects of events. Moving from a concrete representation of a situation to a more abstract representation involves retaining central and global features and omitting features that may vary without significantly changing the meaning of the represented information. Low-level, concrete construals, in contrast, consist of rich, vivid, and specific detail. They emphasize subordinate (vs. superordinate) features of a situation, focusing on local (vs. global) perceptual elements, and—most relevant for the present research—processing information in a detailed-oriented (vs. holistic) manner (e.g., Liberman, Sagristano, & Trope, 2002; Shapira, Liberman, Trope, & Rim, in press; Trope & Liberman, 2000; Vallacher & Wegner, 1989). For example, a high-level construal of playing the piano may consist of the central feature of the situation, which is "making music." In contrast, a low-level construal of the same situation may consist of much narrower segments, such as pressing the keys, lifting the arms, and moving the fingers.

Low-level versus high-level construals make people differentially sensitive to low-level versus high-level features in their environment. When construing a situation on a low level, attention to specific details causes individuals to perceive more changes. A study by Henderson, Fujita, Trope, and Liberman (2006, Study 1) illustrates this effect. Participants were asked to segment a film clip into as many meaningful units as they deemed appropriate. Level of construal affected the segmentation: When the situation was construed on a low level, participants segmented the film clip into narrower and more units than when the situation was construed on a higher level, indicating that participants perceived more meaningful changes. Additionally, Maglio and Trope (2011) showed that concrete construal causes people to use smaller units to measure the spatial length of a target. This finding also suggests that concrete construal causes participants to pay attention to details, as smaller measurement units are more appropriate when construing a target concretely than when construing it abstractly.

High-level versus low-level construal can be procedurally primed (Freitas, Gollwitzer, & Trope, 2004; Fujita, Trope, Liberman, & Levin-Sagi, 2006; Hansen & Wänke, 2010; Wakslak & Trope, 2009). That is, a priming task can trigger subsequent high-level or low-level construals in an unrelated task. For instance, participants who generate superordinate category labels (vs. subordinate exemplars) for a series of words (e.g., *beer*, *pasta*, *book*, *professor*) have been shown to construe information in an unrelated task more abstractly (vs. concretely; Fujita et al., 2006). Likewise, reflecting on why a behavior is done (vs. how) induces abstract (vs. concrete) construals. These and other related tasks prepare participants to construe situations more abstractly or more concretely (for a review, see Trope & Liberman, 2010). Importantly, it is not the semantic content of the priming tasks that influences the level of construal. Instead, the general tendency to construe information abstractly versus concretely is procedurally primed by the tasks.

Additionally, abstract versus concrete construal has been shown to be triggered by a wide range of factors, such as describing an event from a first person or third person perspective (Libby, Shaeffer, & Eibach, 2009) or as temporally, spatially, or socially distant (Liberman & Trope, 2008). Besides experimental priming tasks, there are many factors in real life that elicit abstract versus concrete construals, such as processing fluency (Alter & Oppenheimer, 2008), positive mood (Labroo & Patrick, 2009), ceiling height (Meyers-Levy & Zhu, 2007), and states of relaxation (Pham, Hung, & Gorn, 2011).

Since concrete (vs. abstract) construal means that the mind attends to concrete features and segments a situation into smaller units and more of them (see also Fujita et al., 2006; Maglio & Trope, 2011; Wakslak, Trope, Liberman, & Alony, 2006), concrete construal should induce subjectively more changes in a given situation. Individuals who are primed with a concrete (vs. abstract) mind-set may therefore experience the situation as shorter. The present Studies 1 and 2 were designed to test whether mind-sets affect the estimation of the duration of a situation. We measured (Study 1) or manipulated (Studies 2A and 2B) a concrete versus abstract mind-set and asked participants to estimate the duration of an event. We hypothesized that time would be experienced as passing more quickly for participants who are primed with a concrete mind-set.

However, concrete construal may not always lead individuals to perceive time as short. This is because actual changes in a situation may take place on a lower level or on a higher level. Concrete construal shifts attention to low-level changes, whereas abstract construal makes people less sensitive to concrete changes. Conversely, abstract construal shifts attention to high-level changes, whereas concrete construal makes people less sensitive to abstract changes. Thus, if changes pertain to an abstract level, even abstract construal of a situation may lead to experiencing the situation as short. To illustrate this idea, consider someone who reads a text. The reading of the text may be perceived as short for individuals who construe the situation abstractly (e.g., as "gaining knowledge") when the text changes frequently in terms of its content (i.e., changes on a high level). In contrast, for individuals who construe the situation concretely (e.g., as "following the lines of print"), time is experienced as passing more quickly when the text changes frequently in terms of its font (i.e., changes on a low level).

To test this idea, in Studies 3 and 4 we experimentally manipulated actual changes in addition to abstract versus concrete mind-sets. Specifically, we introduced situational variations on a higher level versus a lower level. Since low-level (high-level) changes are more likely to be attended to when construing a situation concretely (abstractly), we hypothesized that situational variations on a low level would affect participants who construe a situation concretely (i.e., who are primed with a concrete mind-set), whereas variations on a high level would affect participants who construe a situation abstractly (i.e., who are primed with an abstract mind-set), as indicated by a decrease of subjective time.

## Overview

In the first three studies (Studies 1, 2A, and 2B), we tested the hypothesis that time is experienced as passing more quickly in a given situation when participants think concretely (vs. abstractly). Two further studies introduced actual changes on a low versus high level (Studies 3 and 4). These two studies tested whether the level on which changes happen interacts with the level of construal.

We used two paradigms to assess time perception: time production and verbal estimation. In the time production paradigm, participants were asked to stop a timer after a certain amount of time (e.g., 30 s). If time is subjectively fast, people should produce longer intervals. In other words, they would be surprised if they were told that the interval is already over. If time is subjectively slow, participants should produce shorter intervals. Here they would have the feeling that the interval must be over even when it is not. In the verbal estimation paradigm, participants were asked to estimate the temporal length of an event (e.g., a movie clip) after its occurrence. If time is perceived as passing quickly, participants should estimate the event as shorter than when time is subjectively slow. Note that depending on which paradigm is used, the measured temporal length has different meanings: When time is perceived as passing quickly, participants produce long intervals in the production paradigm but estimate a situation as short in the estimation paradigm. Previous studies have demonstrated that the degree of temporal underestimation is positively correlated with the degree of interval overproduction (Carlson & Feinberg, 1968, 1970).

Additionally, we measured level of mental construal (Study 1) or manipulated a concrete versus abstract mind-set (Studies 2A, 2B, 3, and 4). In this way, we increased the preparedness to construe information on a certain level (concrete vs. abstract). The mind-set should influence time perception.

## Study 1

In Study 1, we tested whether concrete (vs. abstract) construals are associated with perceiving time as passing quickly. We first assessed individual differences in level of construal. Afterward, time perception was measured with a time-interval production paradigm (Dougherty, Mathias, Marsh, & Jagar, 2005). Specifically, we asked participants to time a specific duration (i.e., 30 s). We hypothesized that participants who tend to construe situations on a concrete level rather than on an abstract level would experience time as passing faster, resulting in a greater underestimation of time (e.g., the perception that only 20 s had elapsed when actually 35 s had passed) and thus in longer produced intervals.

### Method

Twenty-five visitors at an open house in the psychology department of the University of Basel who passed our booth (15 female, 10 male; mean age = 29.44 years, $SD = 12.41$ years) volunteered to participate in a study on "time estimation." After collecting demographic data, we administered the Behavioral Identification Form (Vallacher & Wegner, 1989), which measures the construal level on which participants chronically identify events. This test provides participants with 24 actions (e.g., *reading*) and two alternative descriptions of each action. One of the alternatives always offers a description that emphasizes the concrete, low-level means by which the action is performed (e.g., *following the lines of print*). The other alternative always emphasizes the high-level end for which the action is performed (e.g., *gaining knowledge*). For each action, participants were asked to choose the description that for them expressed the action better than the other. The proportion of end-related choices served as the measure of the tendency to construe events on a higher level.

After completing the Behavioral Identification Form, participants were asked to repeatedly (i.e., three times) stop a timer after 30 s. To record the timed intervals, we used the TIME software developed by Dougherty et al. (2005). This paradigm involves a passive response interval during which participants start a timer by pressing the space key on a computer keyboard, wait during the estimation interval, and respond a second time to stop the timer. During this time participants sat in front of an empty computer monitor. The computer recorded the produced time interval and provided participants with a feedback about their produced duration (in seconds with one decimal place) on the screen after each of the three trials. Participants could infer the accuracy of their produced intervals from this feedback.

### Results and Discussion

The three time productions were averaged into a single score ($M = 29.8$ s, $SD = 5.64$ s; Cronbach's $\alpha = .56$). As expected, a negative correlation was found between the tendency to construe events on a high level and the produced time ($r = -.45$, $p = .026$. This finding is a preliminary indicator that time is experienced as passing more quickly when a situation is construed on a low level, presumably because participants with a tendency to construe events on a low level tend to spontaneously construe their current situation on a low level, as well. This construal may have led them to attend more to concrete features in their environment (such as objects in the room or details of their surrounding), introducing a "richer" situation with more changes that divert attention away from time. Consequently, time passed subjectively more quickly for them than for participants with a tendency to construe events on a higher level.

Separate analyses for each trial show that the variances in the time estimations decreased over time ($M = 29.33$ s, $SD = 11.85$ s; $M = 30.51$ s, $SD = 5.42$ s; $M = 29.56$ s, $SD = 3.15$ s, for the three trials, respectively) as well as the magnitude of the negative correlation between level of construal and time estimation ($r = -.40$, $p = .045$; $r = -.43$, $p = .034$; and $r = -.14$, $p = .51$, respectively, for the three trials). These latter findings are likely due to the feedback, which may have caused participants to calibrate their judgments over the three trials. Therefore we refrained from providing participants with feedback about their estimates in the next study.

## Studies 2A and B

In Studies 2A and 2B, we manipulated an abstract versus concrete mind-set with two established methods (Freitas et al., 2004; Fujita et al., 2006; Wakslak & Trope, 2009) instead of measuring the chronic tendency to construe events on a high versus low level. To quantify time estimates, in Study 2A we used the interval production paradigm as in Study 1. In Study 2B, we assessed a verbal time estimate (cf. Zakay, 1990). We hypothesized that participants in a concrete mind-set would produce longer time intervals in Study 2A and would respond with smaller estimates in Study 2B.

### Method

Thirty-eight undergraduate psychology students from the University of Basel participated in Study 2A (34 female, four male;

mean age = 21.11 years, *SD* = 1.47 years). Fifty-one New York University (NYU) undergraduate psychology students participated in Study 2B (42 female, nine male; mean age = 19.45 years, *SD* = 1.14 years).

In Study 2A, participants first completed a mind-set priming manipulation developed by Freitas et al. (2004). Participants in the abstract mind-set condition were asked to consider in four successive steps *why* they would engage in an activity (i.e., health improvement). In contrast, participants assigned to the concrete mind-set condition were directed to consider in four successive steps *how* they would engage in the same activity. An additional control group was not primed. Research has demonstrated that listing the ends of an action reliably induces abstract construal and listing the means of an action reliably induces concrete construal (e.g., Alter, Oppenheimer, & Zemla, 2010; Freitas et al., 2004; Fujita et al., 2006). After completing the mind-set manipulation, participants did a time production task and stopped a timer three times after 30 s (Cronbach's $\alpha = .70$) as in Study 1. In this study, however, participants did not receive feedback about their estimates to prevent calibration effects.

In Study 2B, construal level was primed with a category versus exemplar task (Fujita et al., 2006; Wakslak & Trope, 2009). Participants were presented with 39 words (e.g., *table*, *book*, *soap*) that appeared consecutively on the screen. In the abstract-construal condition, participants generated a superordinate category for each word by answering the question "____ is an example of what?" Participants in the concrete-construal condition generated a subordinate exemplar for each of the 39 words by answering the question "An example of ____ is what?" Research has demonstrated that the generation of category labels reliably induces abstract construal and the generation of exemplars reliably induces concrete construal (e.g., Fujita et al., 2006). Next, participants watched a 72-s animated movie clip developed by Heider and Simmel (1944; see also Henderson et al., 2006). Immediately after the presentation, participants were asked to estimate the temporal length of the clip. They indicated their subjective estimate in seconds and were instructed not to round their estimate (cf. Hornik, 1984). Additionally, participants were asked how much attention they paid to the movie clip on a scale from 1 (*no attention at all*) to 9 (*full attention*).

## Results and Discussion

**Manipulation checks.** As manipulation checks, two judges blind to condition coded each participant's level of construal based on the abstractness of his or her responses to the why versus how manipulation in Study 2A and to the category versus exemplar task in Study 2B (see also Fujita et al., 2006; Hampson, John, & Goldberg, 1986; Liberman & Trope, 1998). Specifically, in Study 2A, if a response fit the criterion *Y* by *X*, where *X* was the participant's response to the original statement *Y* (i.e., the response was a subordinate means to the original statement "maintain good physical health"), judges coded the response with a score of −1. If a response fit the criterion *X* by *Y* (i.e., the response was a superordinate end served by maintaining good physical health), judges coded the response with a score of +1. If a participant's response fit neither criterion, the response was coded as 0. The codings of each participant's four responses were then summed to create an index of level of construal with a potential range of −4 to +4, and with higher scores indicating more abstract construal. The codings by the two judges were highly correlated ($r = .96$) and were averaged together. As expected, participants' responses to the why questions ($M = 3.65$, $SD = 0.38$) were more abstract compared with their responses to the how questions ($M = -3.61$, $SD = 0.44$), $t(21) = 42.69$, $p < .001$, $r = .99$.

Additionally, we checked whether the responses to the why questions differed from the responses to the how questions in terms of accuracy. In the abstract mind-set condition, if a task was solved perfectly, all four responses to the why questions would be coded with +1, which sum up to 4. Similarly, in the concrete mind-set condition, all four responses to the how questions would be coded with −1, which sum up to −4 if the task was solved perfectly. We defined accuracy as the degree to which the actual responses deviated from the "perfect" value. Accuracy was calculated for each participant. Specifically, we calculated the absolute differences between the abstractness score and +4 in the abstract mind-set condition ($M = 0.35$), and the absolute difference between the abstractness score and −4 in the concrete mind-set condition ($M = 0.39$). These differences did not reliably differ from each other ($t < 1$), suggesting that the two tasks were equally easy.

In Study 2B, responses were coded as follows: If a response fit the criterion "[participant's response] is an example of [target word]," judges coded the response with a score of −1. If a response fit the criterion "[target word] is an example of [participant's response]," judges coded the response with a score of +1. If a participant's response fit neither criterion, the response was coded as 0. Scores of all 39 items were then summed to create an index of abstractness, with a potential range of −39 to +39 and with higher scores indicating more abstract construal. The codings by the two judges were highly correlated ($r = .998$) and were averaged together. As predicted, participants who generated category labels had significantly more abstract thoughts ($M = 31.3$) than those who generated exemplars ($M = -34.1$), $t(49) = 21.75$, $p < .001$, $r = .95$.

As in Study 2A, we checked whether the responses in the category generation task (i.e., the abstract mind-set condition) differed from the responses in the exemplar generation task (i.e., the concrete mind-set condition) in terms of accuracy. In the category generation task, if a task was solved perfectly, all 39 responses would be coded with +1, which sum up to 39. Similarly, in the exemplar generation task, all 39 responses would be coded with −1, which sum up to −39 if the task was solved perfectly. We defined accuracy as the degree to which the actual responses deviated from the perfect value. Accuracy was calculated for each participant. Specifically, we calculated the absolute differences between the abstractness scores and +39 in the abstract mind-set condition ($M = 8.7$) and the absolute difference between the abstractness scores and −39 in the concrete mind-set condition ($M = 5.9$). These differences did not reliably differ from each other ($t < 1$). Further, the category generation task and the exemplar generation task took about the same amount of time ($M = 5.07$ min and $M = 5.28$ min, respectively; $t < 1$). Taken together, these findings suggest that the two mind-set tasks (i.e., the category generation task and the exemplar generation task) were equally easy.

**Time judgments.** Both mind-set manipulations affected the experience of time. Time was perceived as passing more quickly for participants in a concrete mind-set. In Study 2A, they produced larger time intervals ($M$ = 30.98 s, $SD$ = 2.53 s) than participants in an abstract mind-set ($M$ = 26.02 s, $SD$ = 6.56 s), $t(22) = 2.45$, $p = .023$, Cohen's $d = 0.997$. The control group ranged in between the concrete and abstract mind-set groups ($M$ = 28.49 s, $SD$ = 6.73 s) and did not differ significantly from them ($ps > .27$), $F(1, 35) = 2.28$, $p = .117$, $\eta_p^2 = .12$. Since larger time units in the time production paradigm mean that time is perceived as passing quickly, this finding indicates that participants in a concrete mind-set perceived time as passing more quickly than participants in an abstract mind-set. Further supporting the idea that abstract versus concrete construal is related to subjective time passage, the abstractness scores (see Manipulation Checks) significantly correlated with time production ($r = -.47$, $p = .023$). As in Study 1, a concrete construal (compared to an abstract construal) may have led participants to attend more to concrete features in their environment, introducing a richer situation with more changes that divert attention away from time. Consequently, time passed subjectively more quickly.

Interestingly, participants in the concrete mind-set group and in the control group were more accurate in their time production: The duration of their intervals did not differ from 30 s, $t(11) = 1.35$, $p > .20$, and $|t| < 1$, respectively, whereas the produced intervals of participants in the abstract mind-set group differed from the requested 30 s, $t(11) = -2.10$, $p = .06$, Cohen's $d = 0.61$. This finding indicates that in a time production task, perceiving only few changes may indeed result in underproduction of time and thus in a weaker performance (see also Block et al., 2010). Adding changes by a low-level construal of the situation counteracts the tendency to underproduce time, resulting in more accurate intervals.

In Study 2B, participants in the concrete mind-set condition estimated the duration of the movie clip as shorter ($M$ = 38.12 s, $SD$ = 17.81 s) than participants in the abstract mind-set condition ($M$ = 44.5 s, $SD$ = 15.76 s), $F(2, 48) = 4.07$, $p = .049$, $\eta_p^2 = .08$, after controlling for attention paid to the movie, which covaried with time estimation, $F(1, 48) = 10.33$, $p = .002$, $\eta_p^2 = .18$.[2] Again, these findings support the idea that time is experienced as passing more quickly when participants construed a situation on a more concrete level. As in Study 2A, we found that the abstractness scores (see above) significantly correlated with time estimations ($r = .33$, $p = .02$), providing further support for the idea that abstract versus concrete construal is related to subjective time passage.

One limitation of Studies 1 and 2A is that we did not control for counting strategies. It should be noted, however, that the opportunity to use strategies was the same across conditions and thus cannot explain our findings. Moreover, counting was only possible in Studies 1 and 2A but not in Study 2B. In Study 2B, participants were asked for their time estimation without warning, and thus they could not apply counting strategies. Nevertheless, to prevent counting strategies, we used the verbal estimation paradigm in Studies 3 and 4.

## Study 3

In the previous studies, subjective construal of a situation influenced time perception. However, not only are changes in a situation subjectively construed, but they can occur objectively, and at different levels, as well. In Studies 3 and 4, we introduced actual changes in the event to be judged according to its duration. Thereby we varied whether the changes appeared mostly in the high-level features of the presented stimuli or in the low-level features.

Trope and Liberman (2010) postulated that centrality of a feature can be used to distinguish which features of an item or an event are more high level and which are more low level: Changing a high-level feature has a greater impact on the meaning of an object than changing a low-level feature. For example, a lecture would change more when the speaker is changed than when the room is changed, suggesting that the speaker is a higher level feature of the lecture than the room. Likewise, by definition, the meaning of a word (e.g., *bank*) would change more when the category of the concept is changed (e.g., from "furniture" to "financial institution") than when the font color of the word is changed (e.g., *bank* is written in green vs. blue ink), suggesting that normally categories of words are higher level features than font color.

Participants in Study 3 watched a presentation of a list of words, each belonging to one of three categories and written in one of three colors. Since color is a low-level feature and word category a higher level feature of the word, high-level and low-level changes in the presentation could be manipulated as follows. Changes on a high level were introduced by presenting the words in a randomized order (i.e., with a lot of switches between categories) while keeping the colors constant in each of three blocks. Changes on a low level were introduced by presenting the words in random font colors while keeping the word categories constant in the blocks.[3]

Prior to the presentation of the words, mind-sets were manipulated with the *why/how* task (Freitas et al., 2004) as in Study 2A. If participants primed with a concrete mind-set (compared to participants primed with an abstract mind-set) attend more to the low-level aspects of the stimuli and consequently see more variation in the presentation when low-level features change more frequently than high-level features, a concrete mind-set should lead participants to perceive the duration of the presentation as shorter when the low-level features (i.e., colors) change more frequently than the high-level features (i.e., categories).

### Method

Fifty-eight NYU undergraduate students took part in a study in exchange for course credit. They were randomly assigned to a 2 (mind-set: concrete vs. abstract) × 2 (level of changes: low vs. high) design with both factors varied between participants. We

[2] The mind-set manipulation did not significantly affect attention, $F(1, 49) = 1.54$, $p > .22$, and did not interact with attention in predicting time estimations ($\beta = .18$, $t < 1$). However, higher attention scores were significantly associated with longer time estimations ($r = .37$, $p < .01$).

[3] Of course, when categories of the presented words change a lot in the condition where high-level changes were realized, the presented words per se change as well. Therefore, changes in the high-level feature "categories" imply unwanted changes in another low-level aspect—namely in the pattern of the letters—even if colors are held constant across blocks. However, this low-level aspect ("pattern of letters") changes equally often in all conditions and thus should not affect our findings.

excluded six participants because of technical problems with the presentation ($n = 4$) or because they did not complete the priming task ($n = 2$). The remaining sample consisted of 52 participants (40 female, 12 male; mean age = 19.48 years, $SD = 1.04$ years).

Participants first completed the *why* or the *how* mind-set priming manipulation (Freitas et al., 2004) as in Study 2A. Next, they were presented with 60 words that appeared one after the other on a computer screen, each for 1 s. The word list consisted of three word categories. More specifically, we presented 20 body parts, 20 animals, and 20 fruits. A full list of the words can be found in the Appendix. Additionally, each word was presented in one of three font colors (i.e., blue, red, or green). Depending on the experimental condition, changes in the word presentation on a high versus low level were manipulated. That is, the colors were presented in blocks, but the word categories were randomized in one experimental condition. Here many more changes happened on a high than on a low level: Word categories changed repeatedly, but font color changed only twice (i.e., between the blocks). In the other experimental condition, the word categories were presented in blocks, but the font colors were randomized. Here there were more low-level changes than high-level changes: Font colors changed repeatedly, but the word category changed only twice during the presentation. The whole presentation took 60 s. Immediately after the presentation, participants were asked how long they experienced the entire word presentation to be (in seconds).

## Results and Discussion

The time estimates were analyzed with a 2 (mind-set: concrete vs. abstract) × 2 (level of changes: low vs. high) analysis of variance with both factors being between participants. As hypothesized and as can be seen in Figure 1, we found a significant interaction between mind-set and level of changes, $F(1, 48) = 4.42$, $p = .041$, $\eta_p^2 = .08$. When participants were primed with a concrete mind-set, the presentation was experienced as shorter when the colors of the words changed frequently ($M = 34.09$ s, $SD = 10.91$ s) than when the word categories changed frequently ($M = 47.31$ s, $SD = 12.68$ s), $t(48) = 2.10$, $p = .041$, Cohen's $d = 1.12$, for the contrast. When participants were primed with an abstract mind-set, the presentation was experienced as shorter when the categories of the words changed frequently ($M = 44.64$ s, $SD = 15.75$ s) than when the color changed frequently ($M = 49.46$ s, $SD = 19.66$ s), although the latter contrast was not statistically significant ($t < 1$). No other effects were significant in this analysis ($ps > .14$).

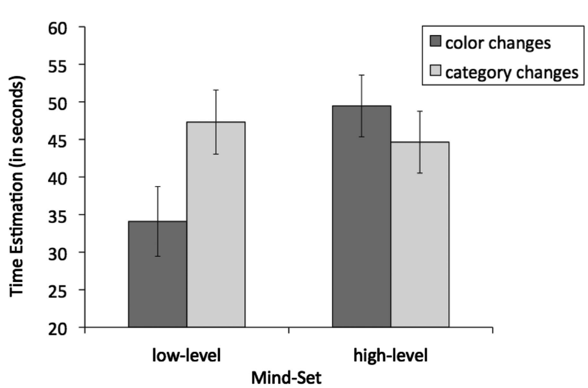


*Figure 1.* Estimated duration (in seconds) of a series of colored words as a function of mind-set (low level vs. high level) and element of frequent change (color vs. category) in Study 3. The actual duration was 60 s.

These findings suggest that time is perceived as passing quickly when changes happen on a level that matches the current mind-set. Low-level changes caused participants in a concrete mind-set to experience time as passing quickly. On the other hand, level of changes had no effect on the time estimations of participants in an abstract mind-set. We would have expected that these participants experienced time as passing quickly when high-level changes were realized. The lack of such an effect for participants in an abstract mind-set may be due to the fact that it is generally harder to detect changes that are conceptual rather than perceptual. It seems that our manipulation of high-level changes (i.e., variations in categories) was too subtle to be detected, and thus too subtle to increase the tendency of participants in the abstract mind-set condition to experience time as moving more quickly. In Study 4, we examined with a different manipulation whether changes on a high level affect the experience of time for participants in an abstract mind-set. Additionally, in Study 3, high-level changes were always conceptual, whereas low-level changes were always perceptual. In Study 4, both levels—high and low—were manipulated perceptually.

## Study 4

Objects can be processed globally by the visual system, according to their overall gestalt, or locally, according to their constituent details. In other words, one can represent "the forest" or "the trees," as the proverbial distinction goes. As noted earlier, global processing is consistent with high-level construal, which is characterized by the ability to extract the essence and see the gestalt, whereas local processing is consistent with low-level construal, which is associated with a focus on the subordinate and incidental elements (Trope & Liberman, 2010). Indeed, using the Navon (1977) letters (i.e., large letters that consist of smaller letters; cf. Figure 2), past research has shown that high-level construals facilitate the processing of the global letter, whereas low-level construals facilitate the processing of the local letters (e.g., Liberman & Förster, 2009; Smith & Trope, 2006).

On the basis of these findings, we used the Navon letters to examine the effect of construal level on time estimates. Specifically, participants in Study 4 estimated the temporal length of a presentation of a series of large letters that consisted of smaller letters. We manipulated high-level versus low-level changes by varying the order of the stimuli so that either the global shapes or the fill patterns of the stimuli changed frequently. Changes of the high-level features were manipulated by randomizing the shapes of the global letters but keeping the local letters constant in blocks. Changes of the low-level features were manipulated by randomizing the local letters but keeping the global letters constant in blocks. Again, participants' mind-sets were manipulated. We hypothesized that time would be judged as passing more quickly when changes happened on a level that matched the mind-set.

## Method

Forty-five NYU undergraduate students (29 female, 16 male; mean age = 19.56 years, $SD = 1.25$ years) took part in a study in

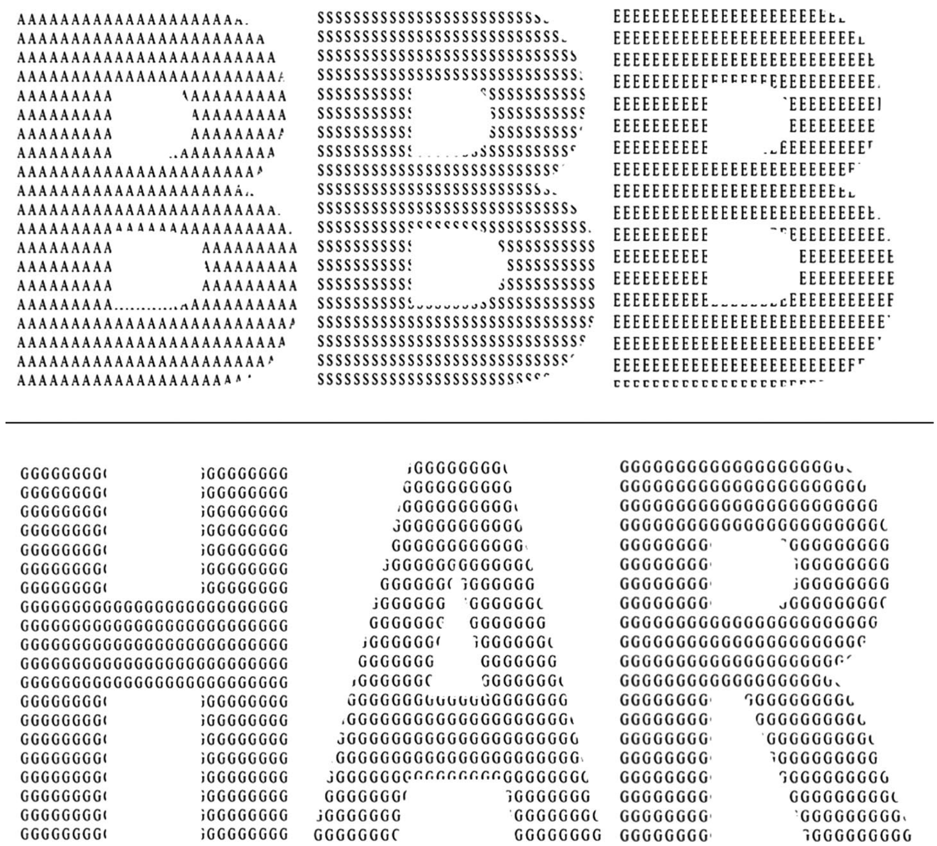

*Figure 2.* Example stimuli used in Study 4. The top row illustrates a sequence with local changes. The bottom row illustrates a sequence with global changes.

exchange for course credit. They were randomly assigned to a 2 (mind-set: concrete vs. abstract) × 2 (level of changes: local vs. global) design with both factors varied between participants.

Participants first completed the category-exemplar task as in Study 2B (cf. Fujita et al., 2006; Wakslak & Trope, 2009). They were asked to name either the higher order category or a low-order example of 39 words. Next, participants were presented with 64 composite stimuli, each comprising a single large letter made up of small letters. Specifically, we presented stimuli that were created from all possible combinations of eight letters randomly drawn from the alphabet (i.e., *A*, *B*, *E*, *G*, *H*, *R*, *S*, and *T*), resulting in 64 stimuli in total. Figure 2 displays examples of the stimuli. The stimuli appeared one after another on the screen for the duration of 1 s each. Depending on the experimental condition, changes in the presentation on a high versus low level were manipulated. High-level changes were manipulated by presenting the shapes of the large letters in a random order across trials while keeping the small letters constant in eight blocks. Low-level changes were manipulated by changing the small letters in each trial in a random order while keeping the large letters constant in eight blocks. In other words, either only the global shape or only the local fill pattern changed frequently during the presentation (i.e., 63 times) while the respective other element changed only rarely (i.e., seven times). Importantly, all participants saw the same stimuli; only the order differed. The whole presentation took 64 s. Immediately after the presentation, participants were asked how long they experienced the entire presentation to be, in seconds.

## Results and Discussion

The time estimates were analyzed with a 2 (mind-set: concrete vs. abstract) × 2 (level of changes: local vs. global) analysis of variance with both factors realized between participants. As hypothesized and as can be seen in Figure 3, we found a significant interaction between mind-set and level of changes, $F(1, 41) = 10.22$, $p = .003$, $\eta_p^2 = .20$. When participants were primed with a low-level mind-set, the presentation was experienced as shorter when the fill pattern of the letter stimuli changed frequently ($M = 38.09$ s, $SD = 16.49$ s) than when the global figure changed frequently ($M = 50.45$ s, $SD = 12.14$ s), $t(41) = 1.82$, $p = .038$, Cohen's $d = 0.85$, for the contrast (one-tailed). When participants were primed with a high-level mind-set, the presentation was experienced as shorter when the global figure changed frequently ($M = 38.0$ s, $SD = 16.64$ s) than when the local fill pattern changed frequently ($M = 56.1$ s, $SD = 17.84$ s), $t(41) = 2.71$, $p = .01$, Cohen's $d = 1.05$, for the contrast. No other effects were significant in this analysis ($F$s < 1). Again, the findings suggest that time is experienced as passing quickly when changes happen on a level that matches the current mind-set. Low-level changes caused participants in a concrete mind-set to experience time as

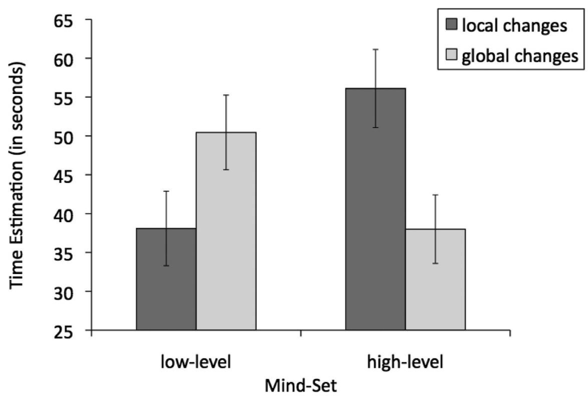


*Figure 3.* Estimated duration (in seconds) of a series of composite letter stimuli as a function of mind-set (low level vs. high level) and level of frequent change (local vs. global) in Study 4. The actual duration was 64 s.

passing quickly. Likewise, high-level changes caused participants in an abstract mind-set to experience time as passing quickly.

## General Discussion

The present research investigated whether mind-set (abstract vs. concrete) affects time perception and how mind-set interacts with changes that actually occur in a given situation. Studies 1, 2A, and 2B demonstrated that a concrete construal of a situation led participants to perceive time as passing quickly, compared to a construal on a higher level of abstraction. This finding was replicated in the conditions of Studies 3 and 4 in which low-level features changed. Additionally, Studies 3 and 4 found that construal interacts with the level on which actual changes happen. Changes on a high level caused participants in an abstract mind-set to perceive time as passing quickly, whereas changes on a low level caused participants in a concrete mind-set to perceive time as passing quickly. In other words, variations on different levels affected time estimation differentially, depending on participants' mind-sets.

Mind-sets were measured by assessing participants' preference for identifying behaviors on a high versus low level, or were manipulated by the *why*/*how* task or the *category*/*exemplar* task. Time perception was measured in two paradigms: time production and verbal estimation. Finally, the level of changes was manipulated by introducing variations of word categories versus colors or by introducing variations of global shapes versus local elements of presented figures. We found convergent results with these different operationalizations: The fundamental cognitive process of time perception was affected by mind-set and by an interaction between mind-set and level of changes.

As noted above, several factors—which have not been related to time judgments so far—promote abstract versus concrete construal, such as describing an event as temporally, spatially, or socially distant (Liberman & Trope, 2008); fluency (Alter & Oppenheimer, 2008); positive mood (Labroo & Patrick, 2009); ceiling height (Meyers-Levy & Zhu, 2007); states of relaxation (Pham et al., 2011); imagining distant versus proximal places and entities (Förster et al., 2004); or visual perspective (Libby et al., 2009). These factors may affect time estimations, as well. For example, do individuals who take a third-person perspective, rather than a first-person perspective, experience time as passing more slowly? Or do individuals in rooms with high ceilings experience time as passing more slowly? Indeed, some past research suggests that time perception is related to spatial distance (e.g., Mitchell & Davis, 1987; Predebon, 2002; Zäch & Brugger, 2008). Future research may further explore whether and how distance and other everyday influences on abstract versus concrete construal affect time judgments.

In Studies 1, 2A, and 2B, concrete construal may have caused participants to perceive more changes than abstract construal (see also Fujita et al., 2006; Wakslak & Trope, 2009), resulting in experiencing time as passing quickly in turn. This finding can be interpreted within the attentional gate model (Zakay & Block, 2004). According to this model, an abstract mind-set would be associated with greater attentional resources devoted to time, and consequently a widening of the gate between the pacemaker and accumulator. This process would result in greater accumulation of pacemaker pulses and thus in a longer experience of time. Individuals in a concrete mind-set, in contrast, would have been more "distracted" by details of a situation. Here fewer attentional resources could be devoted to time, resulting in a narrower gate between the pacemaker and accumulator. This process may have caused smaller accumulation of pulses and thus a shorter experience of time. Attention can also explain the findings of Studies 3 and 4. Participants were first primed to construe a situation abstractly versus concretely, leading them to attend to a particular aspect of the stimuli (high- vs. low-level aspects). Manipulated changes in that particular aspect may have caused participants to devote less attention to time, resulting in underestimation of the temporal intervals.

One could argue that it is not the attention to and perception of changes that makes time seem to pass more quickly but instead the act of segmenting. Participants in a concrete mind-set either may be more likely to attend to low-level changes (as we propose) or may actively segment the situation into finer units. Both processes may result in an increased impression that "a lot is going on." Although the second interpretation is possible in principle, it cannot account for the results of Studies 3 and 4. In these studies, participants were provided with experimental materials that were already segmented (i.e., changes were provided in the materials in some conditions), so that participants did not need to segment the presentation by themselves. Still, time judgments were affected by the provided changes. This suggests that attention to changes per se is sufficient to cause shifts in time perception even without an active act of segmentation.

Our findings that mind-sets affect the experience of time passage have important implications for the many phenomena that relate to time, such as evaluation, planning, and performance. Evaluation of activities, for example, has been shown to be related to experiencing time as passing quickly (Conti, 2001). For instance, Sackett, Meyvis, Nelson, Converse, and Sackett (2010) found that people rated tasks as more engaging and songs as more enjoyable when they had the impression that time passed quickly. In combination with our findings, this suggests that a concrete mind-set would lead to more positive evaluations of situations, particularly when changes take place on a low level. Accordingly, situations in which one is absorbed in one's activity and intensely focused on the concrete here and now—such as situations in which one experiences flow (Csíkszentmihályi, 1990) or is intrinsically motivated (Deci, 1975)—are characterized by both a sense that "time is flying" and enjoyment of the task (see also Higgins, 2006). A concrete construal may help one concentrate on current activities and thereby fosters such states of absorption. An effect of concrete construal on flow or intrinsic motivation may thus be partially explained by experiencing time as passing quickly.

On the behavioral level, the experience of quick time progression may result in quicker performance of actions: When less time is left, one has to be fast to reach one's goals. In line with this reasoning, it has been shown that actions construed more concretely demand earlier enactment than actions construed more abstractly (Liberman, Trope, McCrea, & Sherman, 2007). Moreover, Szymkow-Sudziarska, Parzuchowski, Chandler, Baryla, and Wojciszke (2011) recently found that a concrete mind-set rather than an abstract mind-set caused people to act quicker. Future research may investigate whether this effect is mediated by the perception of time and whether it interacts with the level of changes.

Finally, relating our findings to previous research that demonstrates that time is perceived as passing more quickly when tasks are difficult (e.g., Buchwald & Blatt, 1974; Hanley & Morris, 1982), distracting (e.g., Block et al., 1980, 2010; Block & Zakay, 2008), or changing (e.g., Ahn et al., 2009; Avni-Babad & Ritov, 2003), the results of the present Studies 3 and 4 suggest that any effect of task demands on time perception may be moderated by the level on which the task demands are construed. It would be interesting to see, for instance, whether distraction or task difficulty would have less influence on time perception when it pertains to a higher level of construal or when one is construing situations abstractly.

Admittedly, we created a relatively artificial situation in our studies in order to manipulate high-level and low-level changes independently. In real life, high-level and low-level changes are hierarchically linked. That is, changes on a high level are superordinate to changes on a low level in the sense that the presence of high-level changes often implies low-level changes, whereas low-level changes do not necessarily imply high-level changes. For instance, changes of travel destinations (a high-level feature) imply changes of a specific route (a low-level feature), but not vice versa. Or changes on a global societal level often imply changes in one's local personal environment, but not vice versa. This suggests that—even if high-level changes do exist in principle—low-level changes are much more common in real life. Therefore, people who construe events concretely may be more affected by changes in general than people who construe events abstractly. Thus the main effect found in Studies 1 and 2—that time is perceived as passing quickly when a situation is construed concretely—is probably much more common outside the laboratory than the opposite effect, that time is perceived as passing more quickly when a situation is construed abstractly, even if high-level changes are present.

It should be noted that time judgments can be based either on the experience of time passage or on memory of the events that happened in the period to be judged. Research suggests that the number of changes has a differential impact on memory-based and experience-based estimates: Although a lot of changes make people perceive an interval as short while experiencing the situation, many changes may cause them to represent the same interval as long when they base their temporal estimation on available content information encoded in memory during the time period (e.g., Ahn et al., 2009; Block, 1989; Block & Reed, 1978). This is because a lot of changes induce a richer memory trace that, in turn, increases the remembered duration. So a large number of changes induce a shorter *experience* of time, which goes hand in hand with longer *representation* of time: When many things happened, the situation must have been long. Ahn et al. (2009), for instance, found that participants estimated a slide show with a lot of changes as shorter than a slide show with only a few changes when they were asked immediately after the presentation. After a delay of 3 days when the time judgment can only be memory-based, however, the pattern reversed and the presentation with a lot of changes was estimated as longer.

Furthermore, prospective temporal judgments have been distinguished from retrospective judgments (e.g., Block & Zakay, 1997; Zakay & Block, 2004). For prospective judgments, participants know in advance that they are required to make a temporal judgment. Thus, their judgments are based on the time passage experienced during the period to be judged. Retrospective judgments, in contrast, are unexpected and therefore more likely to be based on what is remembered from a situation. Consequently, they are less likely to be based on the experience of time and more on the retrieved content of the situation.

Both time estimation paradigms used in the present research very likely elicited experience-based judgments: The time production paradigm required a prospective monitoring of time that can be expected to result in experience-based instead of memory-based time judgments. In the verbal estimation paradigm—although retrospective in terms of task procedures—judgments were likely based on the experience of time passage, too. First, this is the case because participants were explicitly asked how long they *experienced* the presentation to be *immediately* after the presentation. Second, studies by Ahn et al. (2009) compared time estimations performed immediately after the interval—which is the method that we used in our studies, too—with time estimations after a delay. These studies showed reliable process differences between immediate and delayed time estimations, supporting the notion that the direct estimate immediately following the interval is indeed experienced based.

Had we used the retrospective verbal estimation with a longer delay (cf. Ahn et al., 2009), however, it is likely that time judgments would have been based on memory rather than on experience. In this case, we would expect the estimated time interval to increase as the number of remembered changes increases. Future research should investigate how the pattern of our findings may change when a truly delayed (i.e., memory-based) judgment is required. We expect that the pattern of results obtained in the present studies will be reversed: More changes will be later remembered when the situation is encoded or retrieved in a concrete mind-set, and thus the situation will be judged as longer, particularly if the changes pertain to a low-level feature.

## Conclusion

The present findings shed light on how concrete versus abstract construal affects time judgments. In combination with the construal of the situation, variation in high- versus low-level aspects of the situation had a differential influence on the very basic cognitive process of time perception: If low-level aspects changed, time was experienced as passing subjectively more quickly when a situation was construed concretely. If high-level aspects changed, time was perceived as passing more quickly when a situation was construed abstractly. Abstract versus concrete levels of construal may possibly affect downstream enjoyment of and absorption in one's activities.

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(*Appendix follows*)

## Appendix

### Stimuli Used in Study 3, by Category

| Body parts | Animals | Fruits |
|---|---|---|
| Cheeks | Bear | Apple |
| Chest | Camel | Apricot |
| Ears | Chicken | Banana |
| Eyes | Cow | Cherry |
| Fingers | Crocodile | Coconut |
| Foot | Dog | Grapefruit |
| Hair | Dolphin | Grapes |
| Hands | Duck | Lemon |
| Head | Eagle | Lime |
| Hips | Elephant | Mango |
| Knees | Frog | Melon |
| Legs | Giraffe | Orange |
| Mouth | Horse | Peach |
| Neck | Lion | Pear |
| Nose | Monkey | Persimmon |
| Shoulders | Pig | Pineapple |
| Teeth | Rabbit | Plum |
| Throat | Seal | Strawberry |
| Toes | Tiger | Tangerine |
| Tongue | Zebra | Watermelon |

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