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Expertise Makes the World Slow Down:

Judgments of Duration Are Influenced by Domain Knowledge

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Abstract

Experts often appear to perceive time differently than novices. The current study thus examined perceptions of time as a function of domain expertise. Specifically, individuals with high or low levels of knowledge of American football made judgments of duration for briefly presented words that were either unrelated to football (e.g., *rooster*), football-specific (e.g., *touchdown*), or ambiguous (e.g., *huddle*). Results showed that high-knowledge individuals judged football-specific words as having been presented for a longer duration than unrelated or ambiguous words. In contrast, low-knowledge participants exhibited no systematic differences in judgments of duration based on the type of word presented. These findings are discussed within a fluency attribution framework, which suggests that experts' fluent perception of domain-relevant stimuli leads to the subjective impression that time slows down in one's domain of expertise.

A hallmark of expertise is the rapidity with which operations are executed. For example, skill acquisition is characterized by a speed-up in task performance that fits a power-law function, and classic theories of skill learning assume that once the "rules" for a skill are learned and practiced, they can be performed quickly and accurately with little attention (Anderson, 1982). As well, domain-relevant perceptual processes may be faster in experts than nonexperts. For example, expert volleyball players are quicker than novices to detect the presence or absence of a volleyball (Allard & Starkes, 1980), expert chess players more quickly identify and count pieces indicative of a check than novices (Saariluoma, 1985), and dog and bird experts are faster to classify exemplars from within their domain of expertise than nonexperts (Tanaka & Taylor, 1991).

Thus, a great deal of evidence suggests that, within their domain of expertise, skilled individuals perform operations more quickly than less skilled individuals and exhibit faster responses on perceptual tasks. What is not evident, however, is whether experts' subjective perception of time differs from novices. Anecdotally, athletes sometimes report that peak performance is characterized by a sense that time was slowed. For example, on a night when he hit two home runs, all-star baseball player Ryan Braun recounted that, "Tonight was one of those nights when the ball kind of slowed down for me" (Haudricourt, 2008). Jackson and Csikszentmihalyi (1999), in their studies of peak athletic performance, report a track athlete describing an 11-sec sprint in a similar manner, "It felt like you'd slowed everything down and made sure everything was right, everything was fluent…It felt real quick, but everything felt slow at the same time" (p. 29). More empirically-based support for these observations comes from several sources suggesting that domain familiarity influences perceptions of time. For example, research investigating judgments of duration (JODs) for briefly presented stimuli

indicate that frequent words are generally given longer JODs than less frequent words (e.g., Warm & McCray, 1969), words are given longer JODs than nonwords (Reber, Zimmerman, & Wurtz, 2004), and previously studied words are given longer JODs than words that have not been studied recently (Witherspoon & Allan, 1985).

We suggest that these data fit within an attributional framework that has been proposed to explain the link between perception and memory (e.g., Jacoby, Kelley, & Dywan, 1989; Kelley & Rhodes, 2002). In particular, this framework suggests that the fluency (ease) with which a stimulus is processed influences our perception, such that fluent processing of a stimulus is attributed to a feature of the present environment. For example, Witherspoon and Allan (1985) reported that participants made longer JODs for words that had been recently studied. Previously presented words were likely perceived more fluently than words that had not been recently studied, and this fluent perception was attributed to a feature of the stimulus, namely, its duration. Thus, more familiar stimuli will be perceived more fluently than less familiar stimuli and given longer JODs (Reber et al., 2004).

While prior work has examined the degree to which JODs are influenced by features of the stimulus (e.g., stimulus familiarity) or experimental context (e.g., presentation duration), very few studies have examined individual differences in time perception (cf. Fink & Neubauer, 2005). However a focus on subject-level variables is fruitful as it serves to constrain and extend theory (Cronbach, 1957). For example, if JODs are influenced by stimulus familiarity, then the degree of knowledge an individual has in a particular domain should influence the perception of duration for stimuli from that domain. To this end, in the current study we examined whether individuals who differed in their knowledge of American football perceived time differently as a function of their level of expertise. Specifically, high- and low-knowledge participants made

JODs for rapidly presented words that were related and unrelated to American football. If expertise/knowledge influences the perception of time, then high-knowledge participants should judge football-related terms to be presented for a relatively longer duration than words that are weakly or entirely unrelated to American football. In contrast, we expected that participants low in football knowledge would exhibit no systematic differences in JODs based on the type of word presented. To our knowledge this is the first investigation of individual differences in time perception as a function of expertise.

Method

Participants

One hundred and forty-four Colorado State University psychology students (84 females) participated for partial course credit. Participants were tested individually.

Materials

Eighty words were selected for presentation. Forty of these words (*control items*; e.g., *cheekbone*, *rooster*) had no relation to American football, 20 words (*ambiguous items*; e.g., *huddle*, *interception*) had uses within American football as well as other contexts, and 20 words (*specific items*; e.g., *touchdown*, *pigskin*) were primarily or exclusively used in the context of American football. All three sets of items were equated for hyperspace analog to language log frequency (M = 6.26; see Balota et al., 2007), number of letters (M = 7.44), and number of syllables (M = 2.09). Further, each set was randomly split in half and equated on the dimensions previously noted. These subsets were presented equally often for 46 or 66ms during the test phase.

All participants were also administered a 30-item multiple-choice football questionnaire based on a questionnaire used by Castel, McCabe, Roediger, and Heitman (2007). An item

analysis showed strong internal consistency among items ($\alpha = .84$)[1].

Procedure

All stimuli were presented via computer on a 15-in color monitor running at 60Hz. The experiment was conducted in three phases. In the initial, Familiarization Phase, participants were given practice making duration judgments. Each trial began with a screen instructing participants to press the space bar when they were ready to initiate a trial. This was immediately followed by a fixation point (a cross) which remained on the screen for 500ms. A string of 5 characters (Zs) were then presented for 32, 48, 64, or 80ms. The letter string was immediately followed by a visual mask consisting of 5 large asterisks for 500ms, presented in the same location as the characters. Participants were then prompted to enter a judgment of duration (JOD) by pressing the 1 (*briefest duration*), 2, 3, or 4 (*longest duration*) key. The scale was always visible to participants when making a JOD and the latency to make each judgment was recorded. Ten trials of each duration (40 in total) were presented in a random order during the Familiarization Phase.

Immediately following the Familiarization Phase, participants moved on to the Practice Phase. Participants were informed that we were interested in their ability to judge the duration of briefly presented words and that this phase was intended to provide practice with that task. The procedure was the same as that for the Familiarization Phase with two exceptions. First, a set of 10 words, unrelated to those later presented in the test phase, were presented as stimuli for judgment. Second, only two presentation durations (46 and 66ms) were used. Thus, half of the words were presented for 46ms and half for 66ms in a random order. Participants were not informed that only two stimulus durations were used (cf. Witherspoon & Allan, 1985).

After completing the Practice Phase, participants moved on to the Test Phase. The Test Phase was identical to the Practice Phase, with the exception that participants made JODs for the *control*, *ambiguous*, and *specific* items described previously, presented in a random order. Following the Test Phase participants completed the NFL Questionnaire.

Results

Response latencies of 200ms or faster were excluded from all analyses, resulting in the exclusion of 6.95% of trials. Further, we excluded 27 participants who had more than 15% of their data trimmed for this reason. Thus, 117 participants were included in all subsequent analyses. With respect to performance on the NFL questionnaire, there was no difference between participants who were excluded from further analyses (M = 21.26) and those who were retained (M = 20.56), F<1 (the alpha level for all statistical tests was set to .05).

Football Knowledge. The median score on the football questionnaire was 20.0. Fifty-eight participants with a score below 20 were assigned to the *low-knowledge group* (M = 16.02) and 59 participants who scored 20 or above were assigned to the *high-knowledge group* (M = 25.02). A follow-up test confirmed that the groups' scores reliably differed, $F(1,115) = 282.61$, *Cohen's d* = 3.14.

Familiarization Phase. Mean JODs for the familiarization phase are presented in Table 1 for high-knowledge and low-knowledge participants and were analyzed in a 2(Presentation Duration: 32ms, 48ms, 64ms, 80ms) x 2(Knowledge: high, low) mixed-factor analysis of variance (ANOVA). These data showed that JODs increased with increases in Presentation Duration, $F(3,345) = 140.03$, $\eta^2_p = .55$, and that JODs did not vary as a function of Knowledge, $F(1,115) = 1.72$, $p = .19$, $\eta^2_p = .02$. However, a marginally reliable Presentation Duration x Knowledge interaction was present, $F(1,115) = 2.52$, $p = .06$, $\eta^2_p = .02$. Specifically, low-

knowledge participants made reliably longer JODs for the 32ms presentation duration than high-knowledge participants, $F(1,115) = 4.24$, $\eta^2_p = .04$. Though a similar trend was apparent for low-knowledge participants to make longer JODs for other presentations durations, only the difference for the 32ms condition was reliable (all other Fs ≤ 2.03, ps $\geq .16$).

Test Phase. Mean JODs for the test phase are presented in Table 2. Because a trend was evident for low-knowledge participants to make longer JODs than high-knowledge participants for neutral stimuli (particularly those presented at the shorter durations), any differences between groups in the Test Phase might be masked by differences in the use of the scale for JODs. It is unclear why this trend occurred but given our interest in relative differences based on the type of item rather than absolute differences between groups, we converted all JODs to z-scores based on the overall mean and standard deviation of JODs for each participant (see Avant & Lyman, 1975, for a similar conversion). Because Presentation Duration did not interact with Knowledge, we collapsed across Presentation Duration in the analyses reported[2]. Thus, mean JODs for the transformed data (Figure 1) were analyzed in a 2(Knowledge: high, low) x 2(Item type: control, ambiguous, specific) mixed-factor ANOVA. These data showed that JODs differed as a function of Item type, $F(2,230) = 8.19$, $\eta^2_p = .07$, and that, overall, high-knowledge participants ($M = .03$) made reliably higher JODs than low-knowledge ($M = .00$) participants, $F(1,115) = 10.61$, $\eta^2_p = .08$. More importantly, Item type interacted with Knowledge, $F(2,230) = 5.60$, $\eta^2_p = .05$. We note that this interaction also obtains for the untransformed data, $F(2, 230) = 6.72$, $\eta^2_p = .06$, suggesting that it is not an artifact of the transformation used.

Follow-up tests conducted on the transformed data to explore this interaction showed that JODs did not differ by Item type for low-knowledge participants, $F(2,114) = 1.89$, $p = .16$, $\eta^2_p = .05$, but did differ by Item type for high-knowledge participants, $F(2,116) = 10.23$, $\eta^2_p = .15$. In

particular, for high-knowledge participants, specific items were given higher JODs than control items, $t(58) = 4.23$, *Cohen's d* = 1.01, and ambiguous items, $t(58) = 1.95$, $p = .06$, *Cohen's d* = .37. As well, high-knowledge participants made longer JODs for ambiguous compared to control items, $t(58) = 2.70$, *Cohen's d* = .64. Low-knowledge participants, in contrast, did not exhibit any differences in JODs as a function of Item type[3]. Thus, consistent with our hypotheses, only high-knowledge participants made longer JODs for items related to American football, experiencing the words related to football as having been presented longer than other words. Correlational data are also consistent with these conclusions. Specifically, scores on the football questionnaire were positively correlated with JODs for specific items, ($r = .21$; $p = .03$) and negatively correlated with JODs for control items ($r = -.28$; $p = .003$).

General Discussion

The current study investigated whether the perception of time differs for experts compared to nonexperts. Specifically, participants with high or low levels of knowledge of American football made judgments of duration (JODs) for briefly presented words that were related or unrelated to American football. Results showed that high-knowledge individuals regarded football-specific words as having been presented for a relatively longer duration than words that were less relevant or entirely unrelated to football. JODs for individuals with less knowledge of football, in contrast, did not differ based on a word's relation to football. In conjunction with other reports that experts' perception of domain-relevant information is faster than that of nonexperts (e.g., Saariluoma, 1985), we conclude that experts' perception of time for domain-relevant information differs from nonexperts. Thus, expertise serves to subjectively slow down the perceived apparent duration of domain-relevant information.

Such data can be explained within an attributional framework (e.g., Kelley & Rhodes, 2002) which holds that subjective experience is the product of attributions concerning the fluency (ease) with which a stimulus is processed. Specifically, fluent processing of a stimulus is attributed to features of that stimulus, including its duration. In the current study, experts' fluent perception of domain-relevant words led to the attribution that such words were presented for a relatively longer duration than other words (cf. Reber et al., 2004). Likewise, this may have also made the perception of control items (i.e., items unrelated to football) appear less fluent, leading to shorter JODs for control compared to ambiguous or specific items for high-knowledge individuals. Thus, the current findings may be placed in the context of a variety of other work (see Zakay & Block, 1997, for a review) showing that nontemporal factors can influence the perception of time. Specifically, domain familiarity influences the fluency with which a stimulus is perceived, which in turn influences its perceived duration. We note that the impact of fluency on cognitive judgments is not inevitable. In particular, when participants are aware of the source of fluency at the time of a judgment, fluency often does not affect performance (e.g., Jacoby & Whitehouse, 1989).

We do not suggest that domain knowledge is the only source of fluency that may impact JODs. For example, several other studies report that stimuli presented in less perceptual noise (Whittlesea, 1993) or with greater perceptual intensity (Goldstone, Lhamon & Sechzer, 1978) are given longer JODs than words presented in heavier perceptual noise or with less intensity, likely because the clarity afforded by less masking or greater intensity enhanced the fluency with which a stimulus was processed. Thus, we suggest that any manipulation which alters the perceived fluency of a stimulus, be it as function of individual differences in domain-knowledge or the perceptual characteristics of a stimulus, may impact the perceived duration of that stimulus. We

note that this explanation is consistent with attention-based accounts of time perception. Attentional theories (Thomas & Weaver, 1975; Zakay & Block, 1996) propose that judgments of duration increase when participants allocate more attention to temporal information than other, nontemporal information. Experts' fluent processing of domain-relevant words may likewise afford them more attention to devote to duration judgments, leading to relatively longer JODs for domain-relevant words.

Overall, the current study indicates that experts perceive stimuli within their domain of expertise as appearing for a longer duration than stimuli which are consistent with their expertise. These data accord with an attributional framework that suggests that experts' fluent processing of domain relevant information leads to the subjective experience that such information is presented for a longer duration than other information. Thus, for the expert within his or her domain of expertise, the world appears to slow down.

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Author Notes

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Footnotes

1 As discussed later, 27 participants were excluded from the analyses reported. Internal consistency among items for the remaining 117 participants was high ($\alpha = .83$).

2 It should be noted that, as would be expected, participants made shorter JODs for words presented for 46 ms (M =-.12) than for words presented for 66 ms (M =.15), $F(1,115)=110.92$, $\eta^2_p = .49$. As well, Duration (46, 66ms) interacted with Item type (control, ambiguous, specific), $F(1,115)=6.88$, $\eta^2_p = .06$. In particular, collapsed across participant knowledge, JODs did not differ by item for the 46ms presentation duration, $F(2,230)=1.69$, $p = .19$, $\eta^2_p = .01$. However, for the 66ms presentation duration, JODs differed by item, $F(2,230)=14.24$, $\eta^2_p = .11$.

3 For completeness we also examined between-group differences in JODs for each Item type. These data showed that high-knowledge individuals made longer JODs than low-knowledge individuals for specific, $F(1,115) = 5.94$, *Cohen's d* = .45, and ambiguous, $F(1,115) = 3.73$, $p = .06$, *Cohen's d* = .36, items. As well, high-knowledge participants made reliably shorter JODs for control items than low-knowledge participants, $F(1,115) = 10.73$, *Cohen's d* = .61.

Table 1. *Mean judgments of duration during the Familiarization Phase for high- and low-knowledge participant by Presentation Duration.*

Expertise	32 ms	48 ms	64 ms	80 ms
High Knowledge	1.65 (.07)	1.86 (.07)	2.10 (.07)	2.52 (.07)
Low Knowledge	1.88 (.09)	2.01 (.08)	2.19 (.08)	2.54 (.08)

Note: Standard errors are in parentheses.

Table 2. *Mean Judgments of Duration by Item Type and Expertise*.

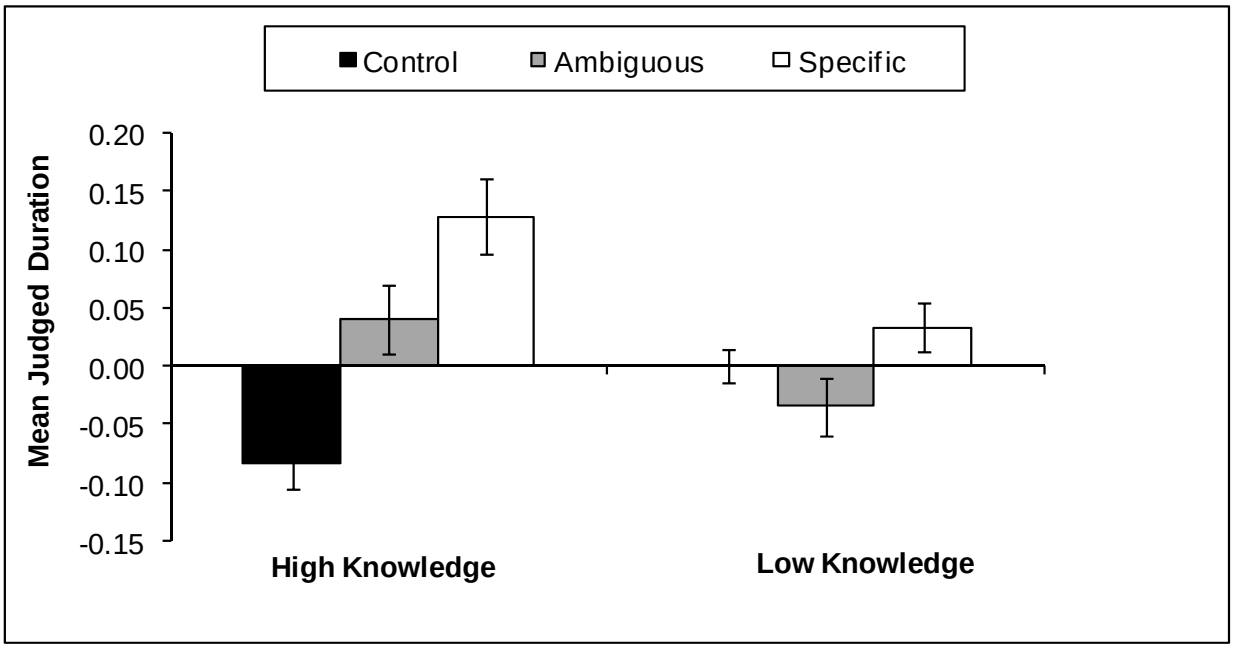
Expertise	Control Items	Ambiguous Items	Specific Items
High Knowledge	1.87 (.05)	1.98 (.06)	2.06 (.07)
Low Knowledge	1.98 (.05)	1.94 (.05)	2.01 (.05)

Note: Standard errors are in parentheses.

Figure Caption

Figure 1. Mean z-scores for judgments of duration during the Test Phase for high- and low-knowledge participants by Item type.

Figure 1.


Control
Ambiguous
Specific
Mean Judged Duration
0.20
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
High Knowledge
Low Knowledge