When Time Flies: Effects of Skilled Memory on Time Transformation in Rock Climbers

“Flow” is a psychological state in which performers become completely absorbed in their task, actions are performed effortlessly, and the sense of time passage is distorted. A flow state can occur at any level of skill when there is an optimal balance between a perceived challenge and one’s skill level. The current research investigates skilled memory, a possible cognitive correlate of time transformation in flow states. Significant differences were found between novice and expert climbers in memory for a climbing route and the probability of experiencing a flow state in the past. Measures taken immediately following climbs also suggested that experts were more likely to experience both flow states in general and time transformation in particular.

For some people, one of the central motivations for pursuing sports is the feeling of total immersion in the moment. During engagement in activity, the individual experiences complete concentration on the task at hand; time seems to pass at a different rate than normal as the performer experiences time transformation, and the individual reports the calming experience of being “in the zone.” The experience itself is often described as being both optimal and intrinsically enjoyable, that is, the performer has an autotelic experience (Jackson & Csikszentmihalyi, 1999). Csikszentmihalyi coined the term Aflow@ to describe this psychological state of consciousness in which someone becomes totally absorbed in the task they are performing at that time (Csikszentmihalyi, 1975; Csikszentmihalyi & Csikszentmihalyi, 1988). Csikszentmihalyi notes five other characteristics that may be present when a person experiences a flow state: Action-awareness merging refers to a feeling of performing actions effortlessly. A sense of lightness and ease of movement usually characterize this aspect of flow. Clear goals mean that the performer knows exactly what they need to do to be successful in a situation. Ambiguity is removed from the situation. Unambiguous feedback is feedback a performer receives through their body and through environmental cues. In a flow state, the performer may use this feedback to assess the quality of their performance and make corrections required to maintain optimal performance. Sense of control is a feeling of empowerment that a performer experiences while in a flow state. Subjectively, people report that they feel like they cannot make a wrong move. Finally, loss of self-consciousness refers to self-doubt being cast aside. While performing, people in a flow state may feel unconcerned about the quality of their performance or with how others perceive their performance (Csikszentmihalyi, 1975).

A flow state usually occurs at a point of optimal challenge, when there is a balance between the perceived challenge of a situation and one’s perceived skill level. Csikszentmihalyi (Csikszentmihalyi & Csikszentmihalyi, 1988) refers to this as the challenge-skills balance. As illustrated in Figure 1, if the chal-

Figure 1. Challenge-Skills Balance Diagram based on Csikszentmihalyi (1990)
Challenges is perceived to be more difficult than what one's ability can match, then anxiety is likely to be experienced. If the perceived challenge of a task is substantially less than one's skill level, then boredom will probably occur. In order to experience a flow state, a performer needs to feel challenged but also able to meet that challenge. Note that this balance can occur at any level of skill as represented by the diagonal line on Figure 1. Thus, performers at all levels of expertise can find challenge-skills balance and achieve flow. Many of these dimensions of a flow state are reminiscent the characteristics of skilled performance that experts acquire through practice in their domain. Jackson and Csikzentmihalyi discuss the relation between expertise and flow in their recent book on flow in sports and suggest that:

It is only when skills are so well practiced as to have become automatic that one can abandon oneself to spontaneous action and experience flow. The novice skier on a difficult slope is intensely self-conscious and worried: He is concerned about positioning the edges of the skis so that he can turn without falling. And he is unable to forget himself and glide effortlessly. Only after he has become an expert can he do the turns spontaneously and enjoy the run. (Jackson & Csikzentmihalyi, 1999, p. 51).

An open question is to what extent the characteristics of the flow experience might be related to expertise in a domain. How does expertise, and improved information processing ability in particular, affect the experience of a flow state?

**Expertise, Information Processing, and Flow**

Experts have a great deal of experience within a domain, and as a result their information processing becomes more efficient. Classic studies in cognitive psychology have shown how extensive practice improves performance by making the activation of relevant knowledge and procedures more automatic, and allowing trained individuals to perform routine skills without the need for conscious thought (Logan, 1988; Posner & Snyder, 1975). Automaticity may allow someone to become absorbed in the overall experience of a task, and thus skilled performance may contribute to the feeling of complete concentration and the action-awareness merging that accompany the flow state.

Further, with experience, more knowledge is acquired. This knowledge can be declarative, providing the expert with a store of examples of previous experiences, or this knowledge can be procedural, giving the expert a wider variety of skills in their arsenal. However, the power of expert knowledge is not just in the amount of information in the experts' memory but also in the organization and accessibility of those memories (Ericsson & Staszewski, 1989). As experts gather more instances and actions into their knowledge and skill base, it is integrated into coherent knowledge structures, which in turn can be used as retrieval structures. As a result, experts have fast and easy access to a great deal of domain-relevant information, allowing them to excel in tasks related to their domain of expertise (Ericsson & Kinstch, 1995).

Across a number of domains, including chess, math, physics, and many sports, it has been demonstrated that experts have the ability to perceive a great deal of domain-relevant information quickly. For instance, in the classic demonstration of expert ability, chess masters were found to be able to reproduce large patterns of chess pieces after only a few seconds of viewing (Newell & Simon, 1972). A-chunking refers to that ability of an expert to recognize groups or sequences, rather than the individual pieces of a situation or task. Using patterns available in their rich knowledge base, experts are better able to perceive meaningful relations in incoming stimuli, and these patterns help them to remember information in chunks (Chase & Simon, 1973; Chi, Glaser, & Farr, 1988; Ericsson & Smith, 1991). Both better pattern recognition and memory allow for experts to be more efficient when solving problems. Experts are faster than novices at assessing and solving problems related to their field, and also have better planning and metacognitive awareness as they solve problems, which may also be due to their specific domain-related experiences (Glaser & Chi, 1988).

Expertise may be related to the flow experience in a number of ways. First, just as experts experience better metacognitive functioning due to their experience, it seems that the clear goals and unambiguous feedback dimensions within the flow state may also be directly related to experience. Second, as noted previously, the effects of automaticity that come from practice at a skill may be directly responsible for action-awareness merging and complete concentration aspects of the flow state. However, the relation between other aspects of the flow state and expertise are less clear. In particular, in the following study we are interested in how expertise, and skilled memory in particular, may affect the perception of time transformation. The possible connections between these aspects of flow and expertise are discussed in detail below.

**Cognitive Technology**
**Expertise and the Perception of Time Transformation**

One way that expertise may influence the experience of a flow state is through an effect of skilled expert memory on time transformation. Just as an expert chess player sees sequences of moves rather than individual options for each piece (Chase & Simon, 1973), expert rock climbers may see sequences of movements rather than just an assortment of holds on a rock face. It is possible that chunking may be related to the experience of flow, and especially the characteristic of time transformation, since there seems to be a relationship between the number of details that can be remembered during a given period of time and the perception of time passage.

According to Poppel (1988), when we are absorbed in a task, we are not paying attention to the passage of time. Hence time seems altered. Poppel asserts that our awareness is broken down into three-second Abites. Our perception of time passage is a compilation of these three-second bites retrieved from memory, rather than a perception based on the experience of the moment itself. As we assemble these bites, we assess the amount of time that has passed by noticing the number of individual memories that we recall for a given period. If a large number of memory units are retrieved for a given period, then time seems to have slowed (time expansion). If a small number of memory units are recalled, then time seems to have flown by (time compression). In other words, our perception of time passage seems to be related to a ratio of individual memories available per three-second time periods.

In a flow state, a performer experiences an altered sense of time passage. Jackson and Csikszentmihalyi (1999) suggest that differences in time transformations may occur across different pursuits. For example, time may pass quickly for a runner who may feel that a marathon lasted a matter of minutes, while it actually took several hours. Time might pass slowly for a baseball batter who might notice the baseball coming at him as if it were traveling in slow motion. He may even notice the stitching on the baseball as it is traveling toward him. It is a plausible hypothesis that the experience of time expansion or compression may be determined in part by the amount of details that require attention for successful performance.

However, another source of differences in how time transformation is experienced may be related to the level of expertise. An expert with the ability to chunk incoming information into larger meaningful sequences or configurations does not need to attend as many individual details as compared to a novice. This might influence a performer to have a sense of time compression while they are in a flow state. Alternatively, when a task is quite difficult and requires effortful, controlled attention to detail, then a performer may experience time expansion, as they will have an elaborate memory for a large number of the exact details of the task. Thus, the ability to easily integrate incoming information into easily accessible structures in long-term memory may also have a direct influence on the perception of time transformation and the experience of a flow state.

**Current Research**

The current research examines the relation between expertise, skilled memory, and the experience of time transformation in flow states in rock climbing.

Our hypothesis is that the perception of time transformation may be related to expertise. Expert climbers should be able to break a climbing route down into a few large “chunks” or sequences of movements rather than many smaller chunks or units based on individual movements themselves. Thus, while expert climbers may have good overall memory for a climb, their memories may be stored in chunks, meaning they may not recall a particular climb in as many individual units. Automaticity may also play a role in the time compression experienced by expert climbers. Since automaticity allows skills to be performed automatically, experts may not need to pay close attention to every movement they make while climbing. As a result, experts will have fewer individual instances of memories in relation to their climbs, and therefore may be more likely to experience time compression and underestimate the amount of time required to complete a route.

Alternatively, when a route is difficult and requires focused attention, then expert memory could allow performers to attend to and represent a great number of details about the climbs. In challenging instances, experts may possess more detailed memories than novices and therefore might be more likely to experience time expansion.

In order to test this hypothesis about possible cognitive influences on the perception of time transformation, we designed an experiment with expert and novice rock climbers. Participants were given a pre-experimental survey designed to assess their climbing background and past experiences with flow states during climbing. Next the participants were tested for their recall of a brief presentation of a climbing route. After completing this task, the participants climbed two climbing routes, one that was easier relative to their skill level and one that was
more difficult. After climbing, the participants filled out survey questionnaires designed to assess whether they experienced a flow state and were asked to estimate the duration of their climb.

Method

Participants

A total of 24 participants between the ages of 18 and 49 years comprised the sample population for the experiment. Participants were drawn from a local climbing class and from the Portland, Oregon area climbing community. The participants were defined as either expert or novice according to the number of years they had been climbing and the difficulty rating of the hardest climb they had ever completed without falling.

The difficulty of climbing routes are assessed and compared using the Yosemite Decimal System (YDS) scale (Long, 1998). This scale, which is open ended, is based on a decimal system. A climb rated 5.0 represents the easiest of the range, through 5.15a that currently represents the hardest end of the scale’s spectrum. Each tenth indicates an increase of one number grade from 5.0-5.9, pronounced “five-zero” to “five-nine.” At the 5.10 level, the ratings become further broken down into lettered subgrades of a,b,c,d. Therefore 5.10 becomes, 5.10a, 5.10b, 5.10c, and 5.10d; this continues on to the hardest difficulty. The YDS scale was used to classify both participants’ skill level and the relative route difficulty in this experiment.

The novice group was comprised of 13 participants. Four were female and nine were male. The novice group was defined as climbers who climbed at the 5.9 level or less, on the YDS scale, and had at least 3 months, but less than 3 years of climbing experience. The mean age for the novice group of climbers was 23.5 (9.1) years (median 24).

The expert group was comprised of seven participants whom were all males. The climbers in this group had at least 3 years or more of climbing experience and climbed at least at the 5.10a level or harder. The mean age of the expert group of climbers was 30.1 (10.3) years (median 25).

Four participants were dropped because they were at an intermediate skill level that was difficult to classify. One had 15 years of climbing experience but only climbed at a 5.9 rating. The other three had climbed at 5.10 or above but had less than a year of climbing experience. One novice participant did not complete the pre-climb flow survey. Two experts did not complete the easy route and novices did not complete the hard route. One novice did not fill in the post-climb time estimates correctly. Another novice had missing data on the self-report memory and enjoyment measures. Because of the small sample size, cases with missing data were retained in the data set and analyses were computed on available data.

For the novice group, the average YDS rating were between the 5.7 and 5.8 grade level with a standard deviation of one number grade. In the expert group, the average was 5.11b with a standard deviation of one letter grade. (Each letter increment was quantified as a single point increment.) The novice group of climbers had an average of 1.2 (1.4) years of previous climbing. However, all the novice climbers had a minimum of 3 months experience climbing. The expert group climbers had an average of 10 (4.9) years climbing experience. All of the expert group climbers had been climbing for a minimum of 3 years. As would be expected due to the criterion for creating the expert and novice groups, there was a significant difference in the amount of time that the two groups had been climbing, t(18)=6.17, p<.001.

In addition to significant differences on the measures used to determine the expert and novice groups, there were similar differences in other measures related to climbing experience. Experts reported climbing more days per week in season per year, M=3.1, SD=1.7, than novices, M=1.0, SD=1.0, t(18)=3.61, p<.01. They also reported climbing more days per week in the off-season, experts=1.93 (1.17), novices=.31 (.48), t(18)=4.43, p<.001. Experts reported having climbed indoors on more occasions, M=89.86, SD=63.7, than novices, M=16.9, SD=14.2, t(18)=4.03, p<.001. Experts also reported climbing in a wider variety of contexts and conditions, M=5.71, SD=2.4, than novices, M=1.0, SD=.57, t(18)=6.79, p<.001. This suggests that the two groups did differ in expertise and that the variables that were chosen as the basis for categorization were related to other measures of climbing experience.

There was no significant difference in the amount of other sports other than climbing that the two groups participated in, t(18)=1. The novice group participated in an average of 1.8 (1.4) other types of sports outside of climbing. The expert group participated in an average of 2 (1.2) other sports outside of climbing.

Materials

Background questionnaires were comprised of two sections. The first assessed the participant’s past climbing experience, as well as their experience with other sports. The second section was an 18-item flow state scale that assessed whether each participant
had experienced flow states in the past while climbing. This scale was adapted from Susan Jackson's flow state scale (Jackson & Marsh, 1996; See Appendix A) and utilized a 5-point Likert format. In the interest of keeping the experiment under an hour, the survey was shortened and two questions were selected for each of the nine characteristics of the flow state.

The forms used for the memory task included a 5” x 7.5” box in which the participants were to sketch their plan. The form also included a key with various symbols that represented different types of holds. (Figure 3 shows sample sketches of an expert and novice.)

Post climbing questionnaires asked the participants to estimate the amount of time that it took them to complete the route. They were also asked to rate the level of challenge they thought the route presented on a 6-point Likert-style scale from easy to extremely difficult.

In exit questionnaires, participants rated their enjoyment on each route and their relative memory for each route on a 10-point scale. On the final question they were asked to identify on a 6-point Likert-type scale how much they agreed that they were in a flow state for each route. The exact item was AA flow state was a psychological state in which someone becomes totally absorbed in the task they are doing. It is a state in which actions are performed effortlessly and the sense of time passage is distorted. For each of the routes, how well does this statement agree with your experience while climbing the routes?

The artificial climbing wall used for this experiment has the capability of changing the type and positions of holds. Being able to create a variety of route types provided better control over the relative difficulty among the various conditions. Ten climbing routes of varying difficulty on the YDS scale were set up on the climbing wall by an expert route setter. This provided a range of difficulties by which climbing routes could be matched to the skill level of the climber.

**Design and Procedure**

Participants were first asked to fill out the pre-experiment questionnaire. Next the participants were shown climbing route number seven, which was rated at the 5.10a, level YDS. They were allowed to look at the route for one minute. During that time, they were asked to think about how they would go about climbing that route. After the minute was over, the participants were instructed to draw a diagram of how they planned to climb the route on the memory task form. While drawing this diagram, they were not allowed to look back at the climbing route; their drawing was done from memory.

After completing the memory task, participants were asked to climb two routes. The routes were matched to a climber’s skill level. Each climber was given one easy route and one difficult route from the ten possible routes using the background information provided in the pre-experiment questionnaires. For each climber, the rating of the hard route was two grades harder in the Yosemite Decimal System than the participant’s hardest listed climb without a fall, while the easy route was two grades easier than the hardest listed climb without a fall. The participants climbed the easier route first, and then the harder route, while an experimenter timed how long they need to complete the route.

As soon as the participants completed each of these routes they were asked to estimate the amount of time they spent climbing each route and rate the challenge of the route. After completing both routes, participants then completed an exit survey that asked for self-reports of their enjoyment, memory for the details of the climb, and their relative experiences of a flow state between the two conditions.

**Scoring**

The pre-experimental flow frequency survey was scored by obtaining the average score of the 18 items. Three items were reverse coded.

The memory task was scored by awarding points for different components of the participant’s sketches: the overall route direction, the recognition of a key feature, and the number of holds. If the overall shape (direction of the route) was correctly indicated (a curve toward the right), a point was awarded. If the key feature of the route, an outcropping shaped like a diamond, was included, then one point was awarded for any reference to the feature. The participant was awarded two points if they noted the presence of two angled planes or edges, and no points were awarded for no reference. The number of correct holds drawn by the participant was totaled and a point was given for each. Each category of features was analyzed separately and as a composite memory score.

**Results**

**Previous Flow State Experiences**

The pre-experimental flow frequency survey was scored by averaging ratings on each the nine factors (means are presented in Table 1). Overall, expert climbers had higher average ratings (3.84, an aver-
age close to often) on all flow factors combined than did novice climbers (3.3, an average close to occasionally), t(14)=2.85, p<.02. (There are missing data for four novice participants on this measure.) In particular, the experts were more likely than the novices to report previous flow experiences along the dimensions of automatic performance, unambiguous feedback, clear goals, and time transformation.

Table 1: Average Subscale Scores on the Abbreviated Flow State Scale for Novices and Experts

<table>
<thead>
<tr>
<th>Items</th>
<th>Novices</th>
<th>Experts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Challenge Skills Balance</td>
<td>4.15</td>
<td>6.30</td>
</tr>
<tr>
<td>Action-Awareness Merging</td>
<td>5.16</td>
<td>4.83</td>
</tr>
<tr>
<td>Clear Goals</td>
<td>1.6</td>
<td>6.36</td>
</tr>
<tr>
<td>Unambiguous Feedback</td>
<td>7.9</td>
<td>6.08</td>
</tr>
<tr>
<td>Concentration on Task</td>
<td>10.17</td>
<td>7.17</td>
</tr>
<tr>
<td>Sense of Control</td>
<td>8.11</td>
<td>7.00</td>
</tr>
<tr>
<td>Loss of Self Consciousness</td>
<td>3.12</td>
<td>7.50</td>
</tr>
<tr>
<td>Autotelic Experience</td>
<td>14.18</td>
<td>7.08</td>
</tr>
<tr>
<td>Transformation of Time</td>
<td>2.13</td>
<td>7.42</td>
</tr>
</tbody>
</table>

*differences at the .05 level between groups

Memory For Route Features

Overall direction. Six out of seven of the experts but only four out of 13 of the novices indicated the correct overall direction of the route in their sketches. Sample expert and novice sketches are included in Figure 2. The distributions for novice and expert groups were significantly different, X²(1)=5.50, p<.019.

Key feature. Experts tended to notice and indicate the key feature in their sketches to a much greater extent than novices, F(1,18)=4.08, MSE=.84, p<.06. Experts earned an average of 1.7 points for the feature (indicating that most noted both angles), whereas novices earned an average of .8 points (suggesting that most only made a simple reference to the feature and did not note both angle changes).

Number of holds. Experts tended to correctly recall more holds (14.1) than novices (11.2), but this result did not reach significance, F(1,18)=2.92, MSE=13.9, p<.10.

Composite memory score. A composite score was computed based on the fit of the sketches with a scoring key of the route drawn by an expert climber while viewing the route. Half of the score was the percent of individual holds that each climber noted out of the 20 noticed by the expert. The other half of the score was the percent of the configurational features that were noted (out of a possible score of three for noticing both the overall direction of the route and the key feature). Using this composite score, the experts' sketches of the route were found to more closely match the key (78.2% overlap) than the novices' sketches (47.1%), F(1,18), MSE=.05, p<.001.

Estimates and Ratings of Hard and Easy Climbs

For the following analysis, each variable is submitted to a 2 x 2 (route difficulty x expertise) mixed ANOVA, with route difficulty as a within subjects measure and expertise as a between subjects measure.

Time Estimation

As noted in the method section, only five out of seven experts and 10 out of 13 novices have complete data on the time estimation task. In the remaining sample, there were significant differences in accuracy of time estimation between the two groups. The expert group greatly overestimated the amount of time spent climbing the difficult route and underestimated the amount of time that it took them to climb an easy route. Novices showed a small overestimation on both the difficult and the easy route (see Table 2 for means). A 2 x 2 (route difficulty x expertise) mixed ANOVA on the differences between esti-
mated and actual times yielded no main effect for expertise \((F<1)\) but a significant interaction for route and expertise, \(F(1,13)\)=9.01, MSE=3338, \(p<.01\), as well as a significant main effect for route difficulty, \(F(1,13)=6.41,\) MSE=3338, \(p<.03\). Overall, the experts were more likely than the novices to experience time transformation. On the easy routes, experts were more likely to experience time compression, suggesting that experts perceived time to fly by. On the harder routes, experts were more likely to perceive time expansion, suggesting that experts perceived time as slowing down.

Table 2: Mean Post-Climb Measures for Novices and Experts on Easy and Hard Climbs

<table>
<thead>
<tr>
<th></th>
<th>Novices</th>
<th>Experts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Easy</td>
<td>Hard</td>
</tr>
<tr>
<td>Duration Overestimation</td>
<td>15.6</td>
<td>5.6</td>
</tr>
<tr>
<td>Difficulty Rating</td>
<td>2.09</td>
<td>5.0</td>
</tr>
<tr>
<td>(1-easy; 6- extremely difficult)</td>
<td>3.92</td>
<td>2.92</td>
</tr>
<tr>
<td>Flow</td>
<td>6.5</td>
<td>4.25</td>
</tr>
<tr>
<td>(1 - completely disagree; 6 - completely agree)</td>
<td>3.83</td>
<td>7.42</td>
</tr>
</tbody>
</table>

Post-climb Ratings of Climb Experiences

As noted in the method section, only five out of seven experts and 11 out of 13 novices have complete data on the post-climb surveys. Post-climb surveys indicated that both groups perceived the easy route as easier than the difficult route, \(F(1,14)=138.4,\) MSE=275, \(p<.001\). The means for each condition are presented in Table 2. This confirms that our manipulation was effective and that the hard route selected for each climber was matched to that climber’s ability. The interaction between route difficulty and expertise was also significant, \(F(1,14)=7.68,\) MSE=275, \(p<.02\), as novices had more extreme ratings of difficulty on the two routes than did experts.

The exit surveys yielded differences in the self-report ratings of flow experiences between the two groups of climbers. Both groups reported experiencing flow from the easy route (average ratings corresponded to a rating of slightly agree; see Table 2 for means). However, only the expert group seemed to experience flow on the difficult route (an average rating between slightly agree and agree), as the novice group was less likely to report flow than the experts on the difficult route (an average rating representing slightly disagree). The main effect for expertise approached significance, \(F(1,18)=2.38,\) MSE=1.98, \(p<.15\), as did the interaction between route difficulty and expertise, \(F(1,18)=3.28,\) MSE=1.71, \(p<.09\). A post hoc comparison indicated that novices were significantly less likely to report flow on the difficult climb, \(t(18)=2.55, p<.02\).

Further, the expert group reported getting more enjoyment from the harder route than from the easier route (see Table 2 for means). The novice group reported the opposite. This interaction approached significance, \(F(1,17)=3.85,\) MSE=10.4, \(p<.07\).

Finally, both groups reported better memory for the harder routes than the easy routes, \(F(1,17)=11.8, p<.0001\). Experts also tended to report having more detailed memory for both routes, \(F(1,17)=3.13, p<.10\); however, the interaction did not approach significance, \(F<1\). The average self-report memory ratings for each condition are presented in Table 2.

Skilled Memory and Time Transformation

Taken together, the self-report results about memory for each climb on the exit survey and the duration estimates of each climber suggest that experts experience a flow state on easy climbs, and this flow state is accompanied by less detailed memory for the climb and a perception of time compression. On harder climbs, the experts still report being in a flow state, but in this condition they report more detailed memory for the climb and a perception of time expansion. This suggests that the ability to chunk and automatically process, encode, and remember domain-relevant information may relate to the perception of time transformation.

Discussion

Until now, the majority of research on flow states has focused on the subjective or phenomenological experience of optimal performance. The current research examined a possible cognitive correlate of flow, and specifically, whether improved skilled memory in experts is related to flow experiences.

First, the results of the climb recall task replicated the classic skilled memory findings originally found with chess experts (Chase & Simon, 1973) that have been found across a wide range of domains. Expert climbers recalled more information after a brief presentation of domain-related stimuli than novices.

This is presumably because experts have fast and easy access to background knowledge structures, enabling better information processing and pattern recognition at encoding, as well as better memory at retrieval. This result is also consistent with a recent study that found a similar effect in rock climbers (Boschker, Bakker, & Michaels, 2002).

Second, expertise was related to both the perception of flow states as well as the perception of time.
transformation. During the experiment, the expert climbers reported experiencing flow in both easy and hard climbing conditions, while the novice climbers only reported experiencing flow in the easier condition. Further, the construct of time transformation seemed to be significantly influenced by expertise, as time transformation did not accompany all flow states. Novices did not seem to experience time transformation. On the other hand, the experts experienced time as passing quickly on the easy route, while they experienced time as passing slowly on the harder route. Interestingly, the expert climbers reported experiencing a flow state in both the easier and harder climb conditions. This suggests that experts may be able to experience a wider range of types of flow states than novices, as well as the idea that skilled memory may mediate the perception of time transformation. Skilled memory can allow climbers to encode a great many details in a challenging climbing situation, resulting in time expansion. On easy climbs, however, skilled memory allows for the automatic and effortless encoding of domain-related information, resulting in time compression.

These findings suggest that there may be qualitative differences in the types of flow states that people might experience. Because experts have a more extensive store of knowledge and experience at their disposal, they may see many situations as being somewhat familiar and may perceive a challenge-skills balance in a wider variety of situations than a novice might. Alternatively, an expert’s larger store of declarative and procedural knowledge may actually allow them to adapt to a wider variety of situations, allowing them to meet a wider range of challenges than a novice can. As a result, the challenge-skills balance zone may widen with expertise, as shown in Figure 3. The current findings support the idea that experts may be able to experience a broader spectrum of flow state experiences than novices. For novices, the range of situations likely to produce a flow state is narrow, and there is a precarious balance between challenge and competence. When climbing a route high on the optimal challenge dimension, the route demands intense focus that produces a highly enjoyable flow state for experts, and as a result experts may feel as though time slows almost to stop while they intensely focus on every detail of a route. However, when climbing routes are low in the challenge dimension, experts can also experience the flow of effortlessly gliding through a route, while time flies by.

Jackson and Csikszentmihalyi (1999) acknowledge that there are different kinds of flow states and that flow experiences may feel very different across different sports and activities. Our results suggest that differences in flow states may be found even within a sport and those differences may be related to expertise. Further, the extent to which time will seem to fly might also depend on the development of skilled memory processes. In particular, the time transformation factor has been one of the least reliable dimensions in flow state inventories (Jackson & Marsh, 1996). The present results suggest that this dimension of flow may depend on expertise, while the other aspects could be more directly related to a challenge-skills balance that can be achieved within a broader range of levels of expertise.

A potential implication of this work is the issue of how perceptions of these various flow states might affect expert performance and whether these perceptions may be a contributing factor to accidents involving experts. Experts may have different levels of awareness while they are in the zone depending on which kind of flow state they are in. A lack of awareness could possibly lead to an increased possibility of accidents, especially if experts are not aware of where they are on the challenge-skills balance curve. The experience of being in a flow state may make the expert overconfident in some situations. They may feel completely in control, while in actuality they may be operating quite automatically and have little awareness of their actions. Similar to airline pilots who may be more prone to oversights when safety procedures become too routinized (Barsh & Healy, 1993), athletes may also experience negative affects of automaticity and skilled performance.

Although accident rates may be highest among novices, anecdotal reports among rock climbing,
skydiving, and other high-risk sporting communities suggest there may be a second bump in the accident rate among highly skilled athletes and sportsmen. An important question for future research is whether different kinds of errors are found at different levels of expertise and whether they may be related to skilled memory, automaticity, and perceptions of a flow experience. The present results suggest that skilled memory and the experience of time transformation in a flow state may indeed be connected.

References

Authors Note:
This paper is based on an undergraduate research project by the first author at Washington State University, Vancouver. Portions of this paper were presented at the Western Psychological Association meeting in Portland, Oregon, in April 2000. Matt Canham is currently a graduate student in the Department of Psychology at the University of California, Santa Barbara.

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Appendix: Questions on the abbreviated Flow State Survey

While climbing, how often have you experienced the following?

1. I feel as though I know exactly what I have to do to climb a route successfully.
2. Time seems to alter (either slows down or speeds up) while climbing a route.
3. I am not concerned with what others are thinking of me while I was climbing.
4. My abilities match the difficulty of a route.
5. I seem to climb automatically as though no effort is involved.
6. I have a strong sense of what I need to do to climb the route successfully.
7. I am unaware of how well I am climbing.
8. I feel as though I can control my climbing performance.
9. When I am climbing, I have a good idea about how well I am doing.
10. I have total concentration on what I am doing while climbing.
11. I have a feeling of total control.
12. I am very concerned with how I am presenting myself to others while climbing.
13. Time stops while I am climbing a route.
14. The route leaves me feeling great.
15. The challenge the route presents exceed my climbing abilities on the route.
16. I climb automatically without having to think.
17. I am completely focused on the route I am climbing.
18. I love the feeling of doing the route and want to do it again.