Time Estimation in Young Children: An Initial Force Rule Governing Time Production

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Children aged 3 and 5 1/2 years were asked to carry out a response duration task in two sessions under ‘‘minimal’’, ‘‘temporal’’ and ‘‘force’’ instructions. In session 1, they were told to press ‘‘long enough’’ for the temporal instructions and ‘‘hard enough’’ for the force instructions. In session 2, they were asked to press ‘‘longer’’ or ‘‘harder’’ than in the previous session. Results showed that the force instructions, but not the temporal instructions, improved the 3-year-olds’ timing accuracy. Furthermore, when instructed to press harder, 3-year-olds pressed longer. In contrast, 5 1/2-year-olds were more accurate with the temporal than with the force instructions; and when asked to press harder, they did not press longer. These findings suggest that 3-year-olds rely on a certain amount of force to produce correct response durations. The marked dissociation between force and duration only emerges between the ages of 3 and 5 1/2.

In the late nineteenth century, Guyau (1890) claimed that infants’ idea of time stems from the frustration experienced during the interval between crying and the mother’s comforting arrival. More recently, studies using conditioning techniques have demonstrated infants’ ability to regulate their behavior in time (see Pouthas, Droit & Jacquet, 1993). Surprisingly, however, there has been little attention to what children really understand from their early experience. That is, there has been little research on the relation between this primary form of temporal adaptation and knowledge of time. From the cognitive standpoint, duration is considered as a pure formal product of the mind (Michon, 1990; Ornstein, 1969).

In his pioneering experiments on the development of the concept of duration, Piaget (1937, 1946) showed that children cannot correctly estimate time before the age of 8, when they acquire the proper mental operations. Subsequent researchers have reported earlier temporal judgments in simplifying the traditional Piagetian tasks, but have not succeeded in going below the critical age.
of 5 (see Levin, 1992). Therefore, they concluded that children are unable to judge time before the age of 5, after which they become capable of an adult-like representation of absolute time that elapses independently of events.

Although children younger than 5 may not have an adult understanding, they may have some form of knowledge about duration. Fraisse (1948) suggested that before conceiving of time as absolute, children become aware of time as they act, through the continuity of their sensations. Specifically, Fraisse (1948) reported that when asked to reproduce durations between 5 and 20 s, 6-year-olds were more accurate when durations were filled by an action (filled durations) than when they were not (empty durations). Fraisse (1948) argued that empty durations require the concept of absolute time, whereas filled durations involve only the perception of experienced continuity.

In the same way, Richie and Bickhard (1988) assumed that young children’s judgments about durations were not based on inferential reasoning as in older children, but may be a form of direct perceptual knowledge.

Although Fraisse (1948, 1982) considered the possibility that young children may have an intuition of duration derived from action, he denied, like Piaget (1946), that time intuition in 4- to 5-year-olds reflected knowledge of duration per se. Piaget (1946) held that time intuition is merely an evaluation based on the result of accomplished work. First-grade children, who see two racing objects starting and stopping at the same time with one stopping ahead of the other, think that the fastest object has taken more time (Acredolo, Adams & Schmid, 1984; Siegler & Richards, 1979). Fraisse and Vautrey (1952) argued that time evaluation derives from the amount of activity or from the feeling of effort. Young children thus estimate that what is more difficult takes more time. This type of rule, “more force equals more time”, indicates that time is still not differentiated from its content, which may keep young children from correctly estimating or producing time (Arlin, 1986; Levin, 1977; Matsuda, 1989, 1991; Montangero, 1979).

A few recent studies have shown that 3-year-olds are able to construct knowledge about experienced filled durations. Friedman (1990) found that 3-year-olds were able to compare the duration of daily activities such as drinking milk or watching a cartoon by placing a marker on a scale ranging from “a very short time” to “a very long time”, although their judgment lacked precision. Droit (1994, 1995a) showed that 3-year-olds were able to reproduce a response duration learned by following an external clock or by imitating an experimenter. These findings are consistent with Fraisse’s (1948) assumption that young children’s temporal judgments are better with filled than with empty durations.

Droit (1994, 1995a, 1995b) suggested that 3-year-olds’ knowledge about filled durations are implicit; they know how to time their actions but not that their actions take time. In line with Fraisse and Vautrey’s (1952) theory, we assume that young children experience a sensation of effort in filled duration tasks before being able to understand that they are actually producing time. Pouthas, Droit, Jacquet and Wearden (1990) noticed that some children as
old as 7 reported having ‘‘pressed hard’’ when they had produced the required duration of 5 s. Thus, the feeling of effort in a response duration task seems to depend on the age of the child, but also on the target duration. With a short duration, as those used by Pouthas et al. (1990), the press duration spontaneously produced when children pressed hard on a button may coincide by sheer chance with the target duration. In this way, the children could all think that they had pressed hard while it was only the duration of their press which was positively reinforced. Our hypothesis is that this confusion between force and duration is impossible with a longer target duration, at least for children older than 5. To produce a given effort for a long time entails that this effort is extended in time. The children might thus think that they control the duration of their press. However, 3-year-old children, who do not clearly dissociate time from action, and who apply the rule ‘‘more force equals more time’’ might think that they are only using more force, although they are controlling both the force and the time of their press.

The present study aimed at investigating the relationship between young children’s ability to produce accurate response durations and their sensation of producing a force response. Developmentalists now agree that the use of questions is a major methodological drawback to investigating young children’s level of understanding. In this light, we decided to test the effect of three different types of instructions, (a) minimal, (b) temporal, and (c) force, in children aged 3 and 5 1/2 carrying out a response duration task. Participants were tested on two sessions, one with a target duration of 5 ± 1 s and one with a target duration of 10 ± 2 s. In session 1, participants were told to press ‘‘long enough’’ for the temporal instructions and ‘‘hard enough’’ for the force instructions. In session 2, they were asked to press either ‘‘longer’’ or ‘‘harder’’ than in the previous session.

We expected that the 3-year-olds would be more accurate with the force instructions than with the temporal or the minimal instructions on session 1 and 2. The 5 1/2-year-olds were also expected to be more successful with the force instructions than with the other instructions on session 1, but not on session 2. Furthermore, the 3-year-olds, assumed to rely on the rule ‘‘more force, more time’’, should press longer when instructed to press harder. In contrast, the 5 1/2-year-olds should press longer when told to press longer; and when told to press harder, they should press harder, but not longer.

METHOD

Participants

The sample was composed of 60 children: thirty 3-year-olds (15 girls and 15 boys; mean age = 3.4 years, SD = 0.2) and thirty 5 1/2-year-olds (15 girls and 15 boys; mean age = 5.6 years, SD = 0.3). (Data from one additional 3-year-old were not included because the child refused to participate in session 2.) They were recruited from two nursery schools in the center of Clermont-Ferrand, France, serving a middle-class, all white community.
Materials

Each participant sat at a table in front of a monitor and a response box connected to a microcomputer which generated post-trial feedback (smiling or frowning clown faces) and recorded all response measures. To respond, the child pressed with the hand a large red button (5 cm diameter) mounted on a key concealed inside the box. The key was connected to a pressure gauge. The criterion for response onset was set at 0.3 Newtons or more, which was found to be the minimal amount of pressure spontaneously produced by 2-year-old children asked to press on the button. Spontaneous variations in force during button pressing were measured at a 10 ms sampling rate. Measurements were obtained for peak force and pressing duration.

Procedure

Each child participated in two sessions, one per day, each comprised of 30 discrete trials. The inter-trial time intervals were random. At the end of each interval, an audible click indicated that a new trial could be performed.

In session 1, the target response duration was 5 s. Positive feedback (the smiling clown) appeared when the child produced a response duration between 4 and 6 s. Negative feedback (the frowning clown) appeared when the duration was less than 4 s or greater than or equal to 6 s. Trials over 10 s were stopped and the frowning clown appeared. For session 2, the target response duration was 10 s with responses of 8 to 12 s receiving positive feedback, those under 8 s and greater than or equal to 12 s receiving negative feedback, and those of 20 s terminated with the frowning clown.

Each age group was divided into three subgroups following the instructions received. At the beginning of session 1, all children were told: ‘‘You are going to learn to play with this red button. You will be able to try several times. A bell will tell you when you can try. After you try, a clown will tell you if you played well or not.’’ Then, children were told to press ‘‘long enough’’ in the temporal instructions group or ‘‘hard enough’’ in the force instructions group, as following: ‘‘To play well, you must press the button ‘‘long enough’’ (‘‘assez longtemps’’) / ‘‘hard enough’’ (‘‘assez fort’’), and then let go. If you press it ‘‘long enough’’ / ‘‘hard enough’’, the clown will be smiling because that’s very good (the child was shown the smiling clown). If you don’t press ‘‘long enough’’/‘‘hard enough’’, the clown will be frowning because that’s not very good (the child was shown the frowning clown). Now, the bell just rang, so you can try.’’ At the beginning of session 2, the experimenter said: ‘‘Do you remember the game we played yesterday? Let me explain it to you one more time.’’ The experimenter repeated the temporal or the force instructions except that instead of saying ‘‘You must press the button ‘‘long enough’’/‘‘hard enough’’, she said ‘‘You must press the button ‘‘longer’’ (‘‘plus longtemps’’)/‘‘harder’’ (‘‘plus fort’’) than yesterday, and then let go.’’

Children in the minimal instructions group were not told how to press. The experimenter just said: ‘‘If you play well, the clown will be smiling because
that’s very good. If you don’t play well, the clown will be frowning because that’s not very good’’. In session 2, the experimenter also asked the child whether he/she remembered the game and repeated the minimal instructions.

RESULTS

Accurate Responses

Each trial was scored as accurate or inaccurate based on the criteria explained in the method section. An analysis of variance was run over the accurate response rate with three between-subject factors (sex, age, instructions) and one within-subject factor (session).

The analyses of variance revealed significant interactions between age and instructions, $F(2, 48) = 10.79, p = .0001$, and between instructions and session, $F(2, 48) = 22.45, p = .00001$. Furthermore, an age $\times$ instructions $\times$ session interaction was found, $F(2, 48) = 6.63, p = .003$. These interactions subsumed main effects of age, $F(1, 48) = 25.37, p = .00001$, instructions, $F(2, 48) = 21.23, p = .00001$, and session, $F(1, 48) = 9.11, p = .004$. No main effect of sex was observed, $F(1, 48) = 3.07, p = .09$.

Figure 1 plots the accurate response rate for 3- and 5 1/2-year-olds following the instructions received at the beginning of sessions 1 and 2. As reported in Table 1, planned comparisons showed that the 3-year-olds were more accurate with the force instructions than with the temporal or the minimal instructions in each session. On session 1, the 5 1/2-year-olds also had a higher correct response rate with the force instructions than with the temporal instructions. However, on session 2, their performance was better with the temporal instructions than with the force or the minimal instructions. Finally, in the force instructions group, the 3-year-olds produced more correct responses than the 3-year-olds in the temporal instructions group for each session and on session 2 in the minimal instructions group.

Untimed Responses

Untimed responses (less than 1 s on session 1, and less than 2 s on session 2) occur when subjects make no attempt to extend their responses in time, a behavior which is typical of young children in temporal learning. An analysis of variance was run over the untimed response rate with the subject factors described above. A significant interaction between age and instructions was found, $F(2, 48) = 5.33, p = .008$, subsuming the main effects of instructions, $F(2, 48) = 14.64, p = .00001$, and age, $F(1, 48) = 27.73, p = .0001$. As shown in Figure 2, the difference in the untimed response rate between 3- and 5 1/2-year-olds was smaller in force conditions than in temporal or minimal conditions. Also significant was the main effect of session, $F(1, 48) = 5.09, p = .03$. The main effect of sex was not significant.

Response Duration

An additional within-subject factor was introduced here to assess learning effects across sessions. The 30 trials were grouped into five blocks of six
FIG. 1. Percentage of accurate response durations for 3- and 5-year-olds as a function of the verbal instructions given at the beginning of sessions 1 and 2: minimal (MI), temporal (TI), and force (FI).

An analysis of variance was computed on the median response durations\(^1\) with three between-subject factors (sex, age, instructions) and two within-subject factors (session, block). Table 2 presents the median response

\(^1\) An analysis on mean response durations was also performed. The pattern of results was the same as with the median response durations.
TABLE 1
List of Significant Planned Comparisons

<table>
<thead>
<tr>
<th>Variable</th>
<th>df</th>
<th>F Level</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-year-olds, session 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FI vs. MI</td>
<td>1, 16</td>
<td>44.29</td>
<td>.00001</td>
</tr>
<tr>
<td>FI vs. TI</td>
<td>1, 16</td>
<td>19.62</td>
<td>.0004</td>
</tr>
<tr>
<td>TI vs. MI</td>
<td>1, 16</td>
<td>5.01</td>
<td>.04</td>
</tr>
<tr>
<td>3-year-olds, session 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FI vs. MI</td>
<td>1, 16</td>
<td>26.60</td>
<td>.0001</td>
</tr>
<tr>
<td>FI vs. TI</td>
<td>1, 16</td>
<td>12.43</td>
<td>.003</td>
</tr>
<tr>
<td>5 1/2-year-olds, session 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FI vs. TI</td>
<td>1, 16</td>
<td>9.39</td>
<td>.007</td>
</tr>
<tr>
<td>5 1/2-year-olds, session 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TI vs. FI</td>
<td>1, 16</td>
<td>22.60</td>
<td>.0002</td>
</tr>
<tr>
<td>TI vs. MI</td>
<td>1, 16</td>
<td>5.52</td>
<td>.03</td>
</tr>
<tr>
<td>3- vs. 5 1/2-year-olds</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FI, session 2</td>
<td>1, 16</td>
<td>17.88</td>
<td>.0006</td>
</tr>
<tr>
<td>TI, session 1</td>
<td>1, 16</td>
<td>16.83</td>
<td>.008</td>
</tr>
<tr>
<td>TI, session 2</td>
<td>1, 16</td>
<td>20.60</td>
<td>.0003</td>
</tr>
<tr>
<td>MI, session 2</td>
<td>1, 16</td>
<td>4.75</td>
<td>.04</td>
</tr>
</tbody>
</table>

Note. FI: Force instructions; TI: Temporal instructions; MI: Minimal instructions.

The interaction between block and instructions was significant, \( F(8, 192) = 32.31, p = .0001 \); the median response duration increased more across blocks in the force condition than in the temporal and minimal conditions. Age interacted significantly with instructions, \( F(2, 48) = 3.68, p = .03 \). No additional interaction was observed. Subsumed under these interactions were main effects of instructions, \( F(2, 48) = 3.69, p = .03 \), session, \( F(1, 48) = 17.63, p = .0001 \), and block, \( F(4, 192) = 3.47, p = .009 \). The main effects of age and sex were not significant.

Planned comparisons revealed that in the force condition the 3-year-olds produced longer response durations on session 2 than on session 1, \( F(1, 8) = 21.52, p = .002 \), whereas in the temporal condition they did not significantly lengthen their responses between sessions 1 and 2. In contrast, the 5 1/2-year-olds...
olds pressed longer in session 2 than in session 1 only with the temporal instructions, $F(1, 8) = 10.59, p = .01$.

**Peak Force**

The median peak force of button press produced across blocks in sessions 1 and 2 is given in Table 3 for each experimental group. Analyses of variance
TABLE 2
Median Response Duration (s) as a Function of Block in Sessions 1 and 2, for 3- and 5-year-olds Given Minimal (MI), Temporal (TI), or Force (FI) Instructions

<table>
<thead>
<tr>
<th></th>
<th>MI</th>
<th></th>
<th>TI</th>
<th></th>
<th>FI</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Session 1</td>
<td>2.1</td>
<td>2.2</td>
<td>6.5</td>
<td>7.1</td>
<td>1.4</td>
<td>1.4</td>
</tr>
<tr>
<td>Session 2</td>
<td>2.9</td>
<td>3.6</td>
<td>6.2</td>
<td>6.9</td>
<td>2.3</td>
<td>3.5</td>
</tr>
<tr>
<td>Session 3</td>
<td>1.7</td>
<td>1.9</td>
<td>5.5</td>
<td>5.4</td>
<td>3.5</td>
<td>3.6</td>
</tr>
<tr>
<td>Session 4</td>
<td>1.3</td>
<td>1.8</td>
<td>3.6</td>
<td>4.5</td>
<td>4.8</td>
<td>8.8</td>
</tr>
<tr>
<td>Session 5</td>
<td>1.4</td>
<td>1.2</td>
<td>2.8</td>
<td>5.9</td>
<td>6.8</td>
<td>12.3</td>
</tr>
</tbody>
</table>

were conducted with the three between-subject factors (sex, age, instructions) and the two within-subject factors (session, block).

A significant interaction between instructions and session, $F(2, 48) = 8.10, p = .0009$, and between instructions and age was obtained, $F(2, 48) = 7.67, p = .001$. There was no other significant interactions. These interactions subsumed main effects of instructions, $F(2, 48) = 27.93, p = .00001$, session, $F(1, 48) = 3.86, p = .05$, and age, $F(1, 48) = 30.08, p = .00001$. The main effect of sex reached also significance, $F(1, 48) = 7.74, p = .007$, indicating that boys exerted more pressure on the button than girls.

Planned comparisons showed that in the force condition, the 3-year-olds increased the peak force exerted on the button between session 1 and session 2, $F(1, 8) = 4.98, p = .05$, in the same way as they lengthened their response duration. In the temporal condition, no increase in peak force was observed between sessions 1 and 2. Like the 3-year-olds, the 5½-year-olds pressed harder on session 2 than on session 1 only in the force instructions group, $F(1, 8) = 5.27, p = .05$.

DISCUSSION

As in most developmental research on psychological time, our findings indicated a general improvement in the temporal differentiation of response durations between the ages of 3 and 5½. However, they also show that 3-
TABLE 3
Median Peak Force (in Newtons) as a Function of Block in Sessions 1 and 2, for 3- and 5½-Year-Olds Given Minimal (MI), Temporal (TI), or Force (FI) Instructions

<table>
<thead>
<tr>
<th>Session</th>
<th>MI</th>
<th>TI</th>
<th>FI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>3-year-olds</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Block</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>15.0</td>
<td>09.9</td>
<td>15.6</td>
</tr>
<tr>
<td>2</td>
<td>13.5</td>
<td>09.7</td>
<td>16.1</td>
</tr>
<tr>
<td>3</td>
<td>13.0</td>
<td>09.6</td>
<td>15.5</td>
</tr>
<tr>
<td>4</td>
<td>12.3</td>
<td>10.3</td>
<td>14.9</td>
</tr>
<tr>
<td>5</td>
<td>13.7</td>
<td>09.4</td>
<td>14.9</td>
</tr>
<tr>
<td>5½-year-olds</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Block</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>45.5</td>
<td>37.8</td>
<td>14.4</td>
</tr>
<tr>
<td>2</td>
<td>39.6</td>
<td>35.0</td>
<td>15.2</td>
</tr>
<tr>
<td>3</td>
<td>38.2</td>
<td>38.6</td>
<td>12.9</td>
</tr>
<tr>
<td>4</td>
<td>42.2</td>
<td>40.5</td>
<td>14.3</td>
</tr>
<tr>
<td>5</td>
<td>39.9</td>
<td>39.4</td>
<td>14.6</td>
</tr>
</tbody>
</table>

year-olds accurately control the duration of their responses when given verbal instructions about how hard to press on the response button.

Although force instructions distracted children’s attention away from time, they improved young children’s temporal performance more than did temporal instructions. However, whereas this improvement was always observed for the 3-year-olds, it was observed for the 5½-year-olds only on the short-duration session.

In session 1, force instructions focused the 5½-year-olds’ attention on the force of their button pressing, as revealed by the significant increase in peak force. When they pressed hard, their response durations were relatively short. In the temporal condition, press durations were longer as of the first block of trials. However, in the force condition, the children, wanting to see the smiling clown, tried to press as hard as they could. One participant reported: ‘‘I tried to press very hard’’. Their attempts to press hard indirectly led them to produce longer durations, as indicated by the increase of response durations across blocks. By sheer chance, the duration underlying the force response coincided with the reinforced duration. Thus, by controlling their button-pressing force, the 5½-year-olds successfully timed their responses.

The 5½-year-olds’ performance on session 2 proves that they were totally unaware of the temporal consequences of their acts. Indeed, this kind of chance effect did not occur with the longer target duration. Although the
5 1/2-year-olds pressed harder, they still displayed the same temporal pattern of response as in session 1. Ivry (1986) stated that more time is required to make stronger isometric contractions, but the time increase is quite small. Finally, producing an additional button-pressing effort up to the 10 s level implies maintaining that effort, extending it in time, i.e., incorporating duration into action. But, the 5 1/2-year-olds did not confuse ‘‘more time’’ with ‘‘more force’’, so they did not succeed in timing their press when instructed to press harder.

The 5 1/2-year-olds’ failure with the force instructions on session 2 provides evidence that the 3-year-olds in the same condition were controlling both the force and the duration of their press. They significantly lengthened the duration of their press as they increased their peak force. Thus, unlike the 5 1/2-year-olds, the 3-year-olds integrated duration into their additional effort. This finding indicates that 3-year-olds somehow confuse duration and force. However, this confusion is possible only under certain conditions of instructions and feedback. Ferreiro (1971) and Montangero (1977, 1979) pointed out that younger children use the French term ‘‘plus longtemps’’ not only in a temporal sense, but also in a spatial sense. Therefore, they may have thought the French instructions ‘‘appuyer plus fort’’ to mean both force and time. However, the 3-year-olds probably never persisted in this behavioral pattern unless the feedback was positive.

The findings of the present study are consistent with the assumption that children’s duration knowledge is derived from action, when the time being experienced offers resistance and requires an additional effort. Piaget and Fraisse held that this intuitive understanding of time does not allow young children to evaluate how much time has elapsed. Conversely, our study shows that with this kind of knowledge 3-year-olds are indeed able to estimate time. However, in the long-duration session, 3-year-olds’ performances in the force condition were not as good as those of the 5 1/2-year-olds in the temporal condition. Fraisse (1982) explained that only an understanding of time as homogeneous allows subjects to produce stable timing in different contexts. Nevertheless, in our experiment, the effect of feedback played a critical role in the learning of the target duration, as revealed the increase of response durations over trial blocks. We can therefore assume that the 3-year-olds would have produced more accurate durations with a greater number of trials.

The problem remaining is to determine which psychological mechanism accounts for the fact that our 3-year-olds succeeded in evaluating duration with force instructions whereas they failed in most other conditions. One hypothesis is that younger children evaluated duration by means of the proprioceptive feedback provided by the dynamic control they exerted over their own motor acts. This may not come from the rise in force itself, which took place at the beginning of the response, and therefore does not favor the experience of duration (Ivry, 1986). In a study on adult time estimation, Macar and Vitton (1989) showed that a constant response force, whether weak or strong, is not
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conducive to the production of accurate durations. Numerous studies in adults have also demonstrated the lack of a direct relationship between force control and timing (Ivry & Keele, 1989; Keele, Ivry & Pokorny, 1987; Wing, 1988). In a developmental study, Macar and Grondin (1988) found that 5½-year-olds produced more accurate durations when they pressed on a rubber squeezer whose degree of resistance provided more proprioceptive feedback. However, this system of responding did not influence the 3-year-olds, who constantly displayed poor temporal performance (Macar, 1988).

The effect of force instructions on young children’s temporal performance was probably determined by other non-motor variables. Several models have stressed the importance of attention in the processing of temporal information (Zakay & Block, 1995, 1996). In this way, force instructions may lead children to experience time through their own actions and thus to judge time. This is consistent with Droit’s (1994) study which showed better temporal performance in 3-year-olds with filled durations than with empty durations.

One question that can be raised is whether children’s early filled-duration knowledge involves awareness of the duration of actions or events. According to Piaget (1937), time is integrated into all elementary perceptions. Perception always takes time. But time experienced through perception is far from being time itself. Finally, is the awareness of time the critical difference between filled- and empty-duration knowledge?

Droit (1995a) described 3-year-olds’ duration knowledge as implicit. Implicit knowledge is assumed to exist when performance improves but participants remain unable to state the rules governing the situation (Perruchet, 1988). However, the use of implicit knowledge is often inferred from the simple fact that the participant does not verbalize the rule expected by the experimenter (Shanks & St John, 1994). Participants may perform using other explicit knowledge. Our study shows that 3-year-olds’ temporal behavior is not governed by temporal instructions as in older children, rather, it is governed by force instructions. So far, we have claimed that this data reveals the lack of dissociation between duration and action. This corroborates the assumption of an initial implicit time knowledge radically different from the concept of time that emerges at about age 5 (Droit & Pouthas, 1992; Droit, Pouthas & Jacquet, 1990). However, temporal control via force instructions, as described here, may be an indicator of the onset of a long process of time conceptualization. Children’s feeling that something is resisting them through their action may be the first step toward the understanding of duration. Additional research in children under 3 is needed to gain further insight into this issue.

REFERENCES


Received: December 4, 1996; revised: December 19, 1997