

Knowledge Type 6:

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[+/-] E1 [instance_of: A1,  
          rel11: X11, ..., rel1i1: X1i1]  
followed by  
...  
[+/-] En [instance_of: An,  
          reln1: Xn1, ..., relnin: Xnin]  
followed by  
[+] En+1 [instance_of: An+1,  
          rel(n+1)1: X(n+1)1, ..., rel(n+1)j: X(n+1)j]  
implies  
X = Y
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where, $X \in \bigcup_{a=1}^n \bigcup_{k=1}^{i_a} \{X_{ak}\}$, and $Y \in \bigcup_{l=1}^j \{X_{(n+1)l}\}$

The symbol $[+/-]$ in front of an event E means that E may execute or it is in-executable. In other words, the instances of the knowledge category shown by the representation above includes all the combinations of executable and in-executable versions of the events E_1 to E_n . Similarly, $[+]$ in front of an event E means that E is executed and $[-]$ in front of an event E means that E is in-executable (or not executed). To make the representation simpler, if an event is executable we may not add a $[+]$ symbol in front of it i.e. writing $[+] E$ is same as writing E .

Intuitively, a statement of the above category means that if the a sequence of events ($E_{seq} = E_1 \dots E_n$) is followed by the execution of an event (E_{n+1}) then an entity that participates in an event in E_{seq} also participates in E_{n+1} .

Examples from the Winograd Schema Challenge corpus:

1. In the middle of the outdoor concert, the rain started falling, and it continued until 10.

What continued until 10?

Correct Answer: The rain.

Knowledge Instance:

E1 [instance_of: start, theme: X [instance_of: entity]]

followed by

E2 [instance_of: continue, theme: Y [instance_of: entity]]

implies

X=Y

2. Fred watched TV while George went out to buy groceries. After an hour he got up. Who got up?

Correct Answer: Fred.

Knowledge Instance:

E1 [instance_of: lie, agent: X [instance_of: entity]]

followed by

E2 [instance_of: watch, agent: X [instance_of: entity]]

followed by

E3 [instance_of: get up, agent: Y [instance_of: entity]]

implies

X=Y

3. The drain is clogged with hair. It has to be cleaned. What has to be cleaned?

Correct Answer: The drain.

Knowledge Instance:

E1 [instance_of: clog, patient: X [instance_of: entity]]

followed by

E2 [instance_of: clean, patient: Y [instance_of: entity]]

implies

X=Y

4. The customer walked into the bank and stabbed one of the tellers. He was immediately taken to the emergency room. Who was taken to the emergency room?

Correct Answer: The teller.

Knowledge Instance:

E1 [instance_of: stab, patient: X [instance_of: entity]]

followed by

E2 [instance_of: take, theme: Y [instance_of: entity], destination: Z [instance_of: emergency room, instance_of: entity]]

implies

X=Y

5. The customer walked into the bank and stabbed one of the tellers. He was immediately taken to the police station. Who was taken to the police station?

Correct Answer: the customer.

Knowledge Instance:

E1 [instance_of: stab, agent: X [instance_of: entity]]

followed by

E2 [instance_of: take, theme: Y [instance_of: entity], destination: Z [instance_of: police station, instance_of: entity]]

implies

X=Y

Similarly, following are the other examples in this category:

6. I used an old rag to clean the knife, and then I put it in the drawer. What did I put in the drawer?

Correct Answer: The knife.

7. I used an old rag to clean the knife, and then I put it in the trash. What did I put in the trash?

Correct Answer: the rag.

8. Emma's mother had died long ago, and her education had been managed by an excellent woman as governess. Whose education had been managed?

Correct Answer: Emma.

Comment: The first version is adapted from a sentence in the second paragraph of Jane Austen's *Emma*. The original is

Her mother had died too long ago for her to have more than an indistinct remembrance of her caresses; and her place had been taken by an excellent woman as governess, who had fallen little short of a mother in affection.

Note that the original presents two further difficult disambiguation problems, with the second and third "her"'s in the sentence. Winograd schema in the broad sense, since two separated words are replaced.

9. Sam broke both his ankles and he's walking with crutches. But a month or so from now they should be unnecessary. What should be unnecessary?

Correct Answer: the crutches.

10. The dog chased the cat, which ran up a tree. It waited at the bottom. Which waited at the bottom?

Correct Answer: the dog.

11. Jim signaled the barman and gestured toward his empty glass. Whose empty glass?

Correct Answer: Jim.

12. Jim signaled the barman and gestured toward his bathroom key. Whose bathroom key?

Correct Answer: the barman.

13. The drain is clogged with hair. It has to be removed. What has to be removed?

Correct Answer: the hair.

14. I couldn't find a spoon, so I tried using a pen to stir my coffee. But that turned out to be a bad idea, because it got full of ink. What got full of ink?

Correct Answer: The coffee.

15. I couldn't find a spoon, so I tried using a pen to stir my coffee. But that turned out to be a bad idea, because it got full of coffee. What got full of coffee?

Correct Answer: the pen.

16. As Andrea in the crop duster passed over Susan, she could see the landing strip. Who could see the landing strip?

Correct Answer: Andrea

17. Joe saw his brother skiing on TV last night but the fool didn't recognize him. Who is the fool?

Joe saw his brother skiing on TV last night but he didn't recognize him. Who did not recognize?

Correct Answer: Joe.

Comment: From (Lenat 2008). Winograd schema in the broad sense. (The ambiguity is in the noun "fool", not in a pronoun.)

18. Sid explained his theory to Mark but he couldn't understand him. Who did not understand?

Correct Answer: Mark

19. Sid explained his theory to Mark but he couldn't convince him. Who was not convinced?

Correct Answer: Mark

20. Sid explained his theory to Mark but he couldn't convince him. Who could not convince?

Correct Answer: Sid

21. Emma did not pass the ball to Janie although she saw that she was open. Who saw that the other player was open?

Correct Answer: Emma

22. James asked Robert for a favor but he was refused. Who was refused?

Correct Answer: James

23. James asked Robert for a favor but he refused. Who refused?

Correct Answer: Robert

24. Joe paid the detective after he received the final report on the case. Who received the final report?

Correct Answer: Joe.

25. Paul tried to call George on the phone, but he wasn't available. Who was not available?

Correct Answer: George