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Evaluation of Road Space Reallocation Arrangement and Rest Space Installation for Pedestrians and Cyclists Using the Level of Service Concept on Midosuji Boulevard

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Synopsis

The road space reallocation project on Osaka's main street, Midosuji, started in 2017 to realize the concept of human-centered urban spaces in response to the change of social trends and conditions. The pilot project has been undertaken to increase spaces for pedestrians and cyclists. While the "Level of Service" concept was widely employed to evaluate user comfort issues in the transportation field, it is unknown whether it could apply to these space differences and evaluate the reallocation effect correctly. In this study, we show the elements that are not expressed by the Level of Service and are directed towards a more realistic comfort assessment; for example, rest spaces in road designs, and the expected and necessary speed to avoid worsening traffic flow.

Keywords: Pedestrian transportation plan, bicycle transportation plan, Road space reallocation, Level of service, Comfort, Rest space

1. Research Background and Objectives

In recent years, waning interest in owning a car has been observed among young people, along with its use as a mode of urban transport. The reason is, the youth generally demonstrate lower interest in cars. Moreover, people are relatively more concerned of their environmental impact and in addition, they have more interest in healthy activities. This shift has generated a renewed emphasis on walking and cycling activities. On Central Midosuji Boulevard in Osaka, noticeable changes have been observed since it was built decades ago, in the ways people behave in relation to it and also in the state of the surrounding areas. To reorganize Midosuji in accordance with this changing social situation and the needs of the time, a pilot project is undertaken to close one side of the street, widen the sidewalk, and build a bike lane (Figure 1). This place-making project is initiated to consider the comfort of users and to incorporate pedestrian-centric ideas, with the latter guided by the principle of transforming a car-centric streetscape into a human-centric one[1].

Level of Service (LOS) is used as an index to express the comfortability of this kind of space for transportation; the U.S. Highway Capacity Manual[2] (HCM) defines six LOS grades, on the scale of A to F (A represents the best and F represents the worst). However, limiting the consideration to factors related to transportation may not adequately represent the comfortability of a mixed-use space such as Midosuji, with broad spaces for commingled pedestrians and cyclists, which has other spatial features that relate to its changing streetscape and appeal as a place for leisure.

For this study, we focused on road space reallocation and the effect of a rest space on the sidewalk. A direct survey was conducted of pedestrians and cyclists traversing on broad pedestrian-oriented road spaces of Midosuji, with an objective to evaluate the effects of this streetscape reallocation on both groups in terms of transportation, space, and passers-by, using the concept of service levels. Thereby, proposing the place-making elements will further improve the comfortability when the pilot-project segment is extended in the future.

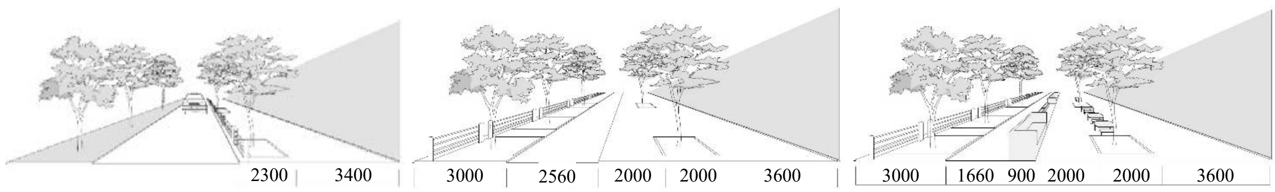

Figure 1: Road space reallocation overview

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2. Research methodology

2.1. Survey overview

To understand the comfortability of pedestrian spaces of Midosuji, Osaka, Japan, we performed surveys on pedestrians and cyclists on three sections: (a) narrow section, (b) wide section without rest space, and (c) wide section with rest space (Table 1). To calculate LOS and assess the traffic situation, a video-based study was conducted, and a questionnaire was administered to gather subjective assessments. Table 3 shows key elements of the questionnaire used for analysis.

Table 3 shows the breakdown of the width of pedestrian and cyclist spaces in each target sections. Figure 2 shows the personal information of the questionnaire survey for pedestrians and cyclists and traffic volume for pedestrians and cyclists on the survey date.

Table 1: Survey overview

	(a) narrow section	(b) wide section without rest space	(c) wide section with rest space
Questionnaire survey	2017/07/22 (SAT) 9:00–19:00 2017/08/04 (FRI) 13:00–19:00 2017/08/05 (SAT) 13:00–19:00	2017/07/22 (SAT) 9:00–19:00 2017/08/04 (FRI) 13:00–19:00 2017/08/05 (SAT)13:00–19:00 2017/12/03 (SUN)11:00–19:00	2017/11/19 (SUN) 11:00–19:00
Video survey	2017/07/22 (SAT) 9:00–19:00	2017/07/22 (SAT) 9:00–19:00 2017/12/03 (SUN)11:00–19:00 ※ to calculate LOS, we use the data on 12/3.	2017/11/19 (SUN) 11:00–19:00
Subject	Pedestrians: n=84 Cyclists: n= 8	Pedestrians: n=93 Cyclists: n=14	Pedestrians: n=79 Cyclists: n=11
Traffic volume at peak hour	Pedestrians: 3,248 p Cyclists: 69 bicycles [The following include cyclists traffic volume on roadway] Cyclists: 213 bicycles	Pedestrians: 3,316 p Cyclists: 316 bicycles [The following include cyclists traffic volume on roadway] Cyclists: 358 bicycles	Pedestrians: 2,727 p Cyclists: 300 bicycles [The following include cyclists traffic volume on roadway] Cyclists: 321 bicycles

Table 2: Contents of Questionnaire survey

Question	Methodology on answer
Comfortability when traveling	1, 2, 3, 4, 5, 6（6 levels）
Importance (whole road)	space, safety, speed, length of road, other users, surroundings 1, 2, 3, 4, 5, 6（6 levels）
Importance (road elements)	path width, verge width, lighting, users speed, volume of pedestrians, volume of cyclists path maintenance, street furniture, surroundings 1, 2, 3, 4, 5, 6（6 levels）
Rest space	I am more comfortable / I am less comfortable / my comfort is unaffected（3 levels）
Expected speed	same as now / slower than now / faster than now（3 levels）

Table 3: Breakdown of streetscape breadth in target segments

		(a) narrow section	(b) wide section without rest space	(c) wide section with rest space
Path width [m]	Sidewalk	3.4 (not separate)	7.6	5.6
	Bicycle lane		2.6	1.7
	Rest space	-	-	2.9
	Trees	2.3	3.0	3.0
	Walkable path width	3.4	10.2	7.3
	Total width	5.7	13.2	13.2

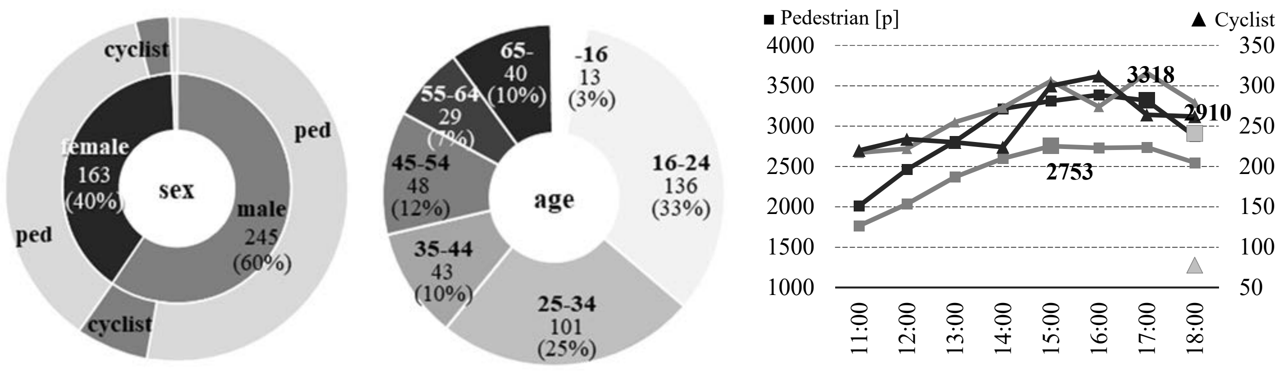


Figure 2: Personal information of questionnaire survey and traffic volume for pedestrians and cyclists

2.2. Analysis methodology

In the questionnaire survey, which serves as subjective indices, respondents scored comfortability on a 6-point scale (1 being very uncomfortable and 6 being very comfortable).

For objective indices, we used the LOS of HCM, which rates density, flow rate, speed, and number of congestion events on each 10-minute peak (Table 4). However, we used the formula based on research by H. Yamanaka et al.[3)] to calculate pedestrian density. In addition, we used cyclists overtaking pedestrians or pedestrians passing each other as the number of congestion events.

The peak time for (a) according to the "Midosuji Pilot Project Study of Cyclist & Pedestrian Traffic Volumes"—which was conducted by the city of Osaka in November–December 2016 and referenced a post-improvement study near the pilot segment used in this study—is 18:30–18:40. Peak times in (b) and (c) were initially measured as 11:00–19:00 for pedestrian and cyclist traffic volume; subsequently these were measured as 17:00–18:00 for (b) and 15:00–16:00 for (c), and from them, the peak time for (b) is 17:00–17:10 and for (c) is 15:00–15:10.

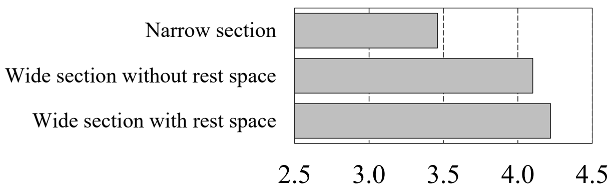
Table 4: Video analysis method for calculating pedestrian LOS

	(a) narrow section	(b) wide section without rest space	(c) wide section with rest space
Time	18:30–18:40	17:00–17:10	15:00–15:10
Density [p/m²]	area: 3.4m(width)×4.5m (length) calculated every 30 seconds	area: 5.8m (width)×17.55m (length) calculated every 30 seconds	
Flow rate [p/min/m]	calculated every 1 minute		
Speed [m/s]	area: 4.5m (length) calculated the passing time for 30 seconds every 2 minutes and calculated the average	area: 17.77m (length) calculated the passing time for 30 seconds every 1 minute and calculated the average	
The number of congestion events [events/h]	$F_p = Q_{sb}(1-\frac{S_p}{S_b})/PHF,\ F_m = Q_{ob}(1+\frac{S_p}{S_b})/PHF,\ F = F_p + 0.5F_m$ F: total the number of congestion events [events/h], F_p, F_m: number of passing / opposing events [events/h], Q_{sb}, Q_{ob}: bicycle flow rate in the same /opposing direction [bicycles/h], S_p, S_b: mean pedestrian /bicycle speed on the path [m/s], and PHF: peal time factor (=0.83) calculated the number of congestion events by using Flow rate and speed		

3. Survey results
3.1. Subjective assessment
3.1.1 Comfort

Figure 3 shows the comfort score for pedestrians and cyclists. Going from segment (a) to (b), the width of the sidewalk affected the comfort score for pedestrians, raising it from 3.46 to 4.10; going from segment (b) to (c), the presence of inviting features slightly increased the score from 4.10 to 4.22. In the HCM, LOS is determined based on the assumption that wider roads increase comfort; while (a) and (b) reflect that trend, (b) and (c) show that comfort can be increased by the presence of inviting features, even when the width is reduced.

For cyclists [(a) to (b)] the width of the sidewalk affected the score, raising it from 2.63 to 3.86; going from segment (b) to (c), the presence of inviting features slightly decreased the score from 3.86 to 3.73. It was greatly affected by the decrease in the path width.



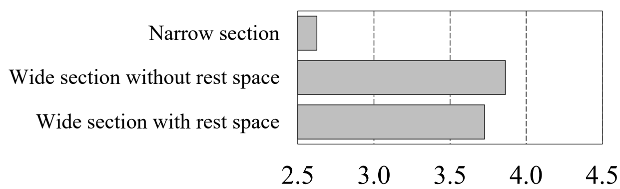


Figure 3: Left; Comfort score for pedestrians (n=369), Right; score for cyclists (n=41)

3.1.2 The factors affecting subjective comfort

Figure 4 shows the importance of factors contributing to comfortability. We can say the following.

Pedestrians:

- The whole road; from the top “safety,” “space,” “surroundings”
- Road elements; “path width,” “volume of pedestrians,” “volume of cyclists,” “surroundings”
- Pedestrians do not feel important about speed elements (e.g. The whole road; “speed,” road elements; “users speed”), however LOS includes the elements.

Cyclists:

- The whole road; from the top “safety,” “space” “other users”
- Road elements; “path width,” “volume of pedestrians,” “volume of cyclists,” “path maintenance”
- Cyclists do not feel important about all elements, except for some, on section (b).

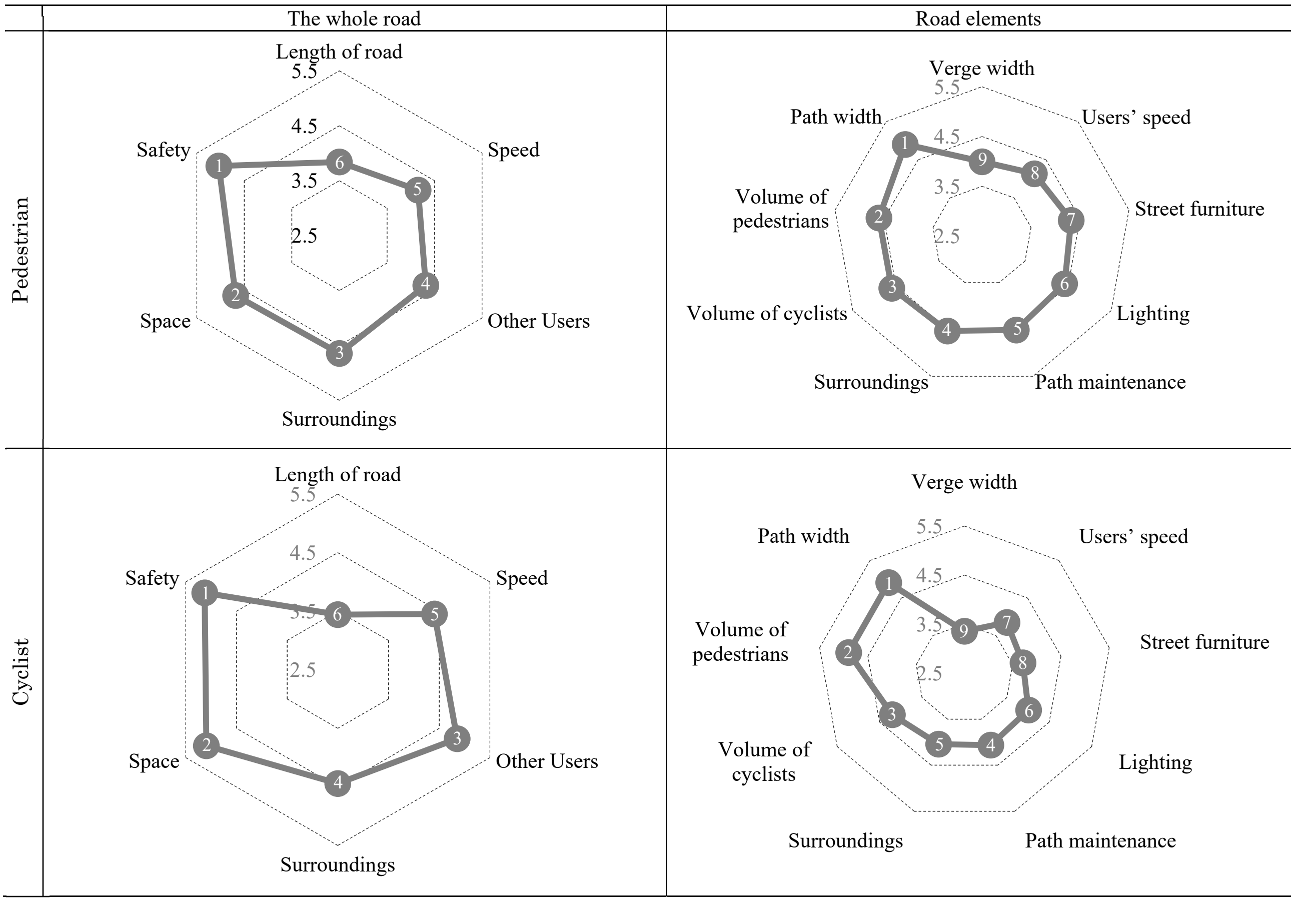


Figure 4: Importance of factors contributing to comfortability; pedestrians; n=370, cyclists; n=39

3.1.3 The rest space

Figure 5 shows the comfort on installing rest spaces. We presented the respondents with the following question: "For each factor below, please rate its importance for your comfort when traveling on a mixed/segregated shared path." For pedestrians, by installing the rest space on the sidewalk, the answer "I am more comfortable" increases 31.0 points from 24.7 to 55.7%, and the answer "I am less comfortable" decreases 15.2 points, going from 21.5% to 6.3% (t=-4.61**, df=170). While for cyclists, the answer "I am more comfortable" slightly increases from 16.7% to 27.2% and the answer "I am less comfortable" is almost unchanged from 25.0% to 27.2% (t=0.27, df=21, *ns*), and the answer "my comfort is unaffected" is nearly half the answers on both sections.

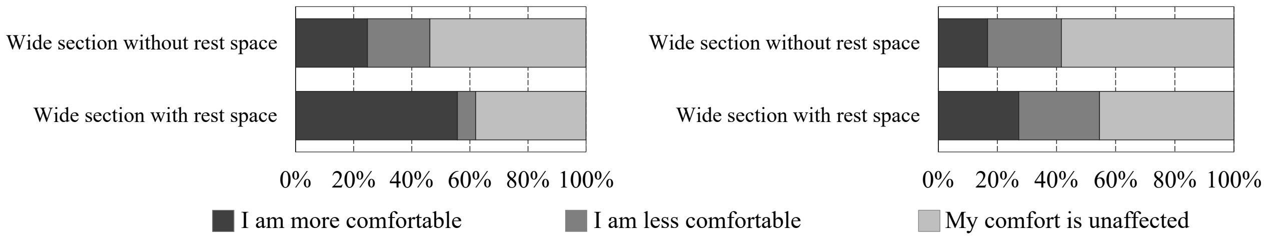


Figure 5: Comfort on installing rest spaces; pedestrians; n=172, cyclists; n=23

3.1.4 The expected speed

Figure 6 shows the expected speed when pedestrians and cyclists are traveling. We presented the respondents with the following question: "What is the speed you want to pass?" For pedestrians, the answer is almost unchanged in the three sections. [(a)(b)t=-0.38, df=270, *ns*、(a)(c)t=0.44, df=156, *ns*、(b)(c)t=0.93, df=268, *ns*] While for cyclists, the answer "Same as now" decreases gradually [(a) 87.5%→(b) 40.9%→(c) 36.4%], and the answer "Faster than now" increases gradually [(a) 12.5%→ (b) 27.3%→(c) 45.5%]. However, no significant difference is found in any sections because of fewer answers [(a)(b)t=-0.16, df=24, *ns*、(a)(c)t=-1.95, df=15, *ns*、(b)(c)t=-1.45, df=25, *ns*].

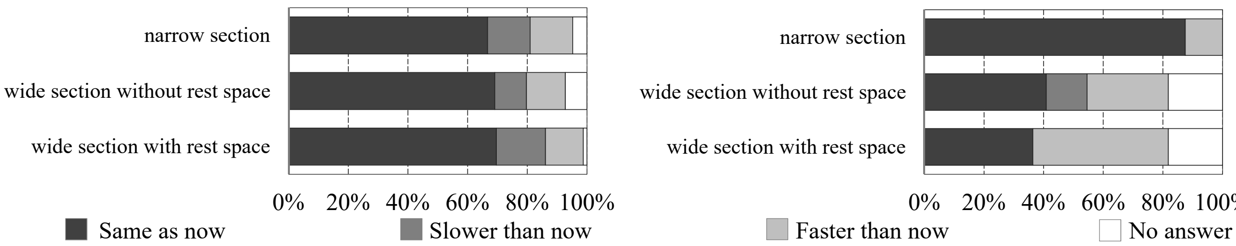


Figure 6: Changing of the expected speed; pedestrians; n=370, cyclists; n=41

3.2. Objective assessment

Figure 7 shows the average LOS scores, based on different criteria, and the LOS rank from HCM. We can say the following.

(a)(b):

- density improved in the LOS rank, however, flow rate and the number of congestion events remained at the rank of A, and the speed was considerably worse compared to other criteria.
- in the LOS score, all of criteria except the number of congestion events improved the traffic flow, in particular, flow rate improved from 14.3p/min/m to 5.8p/min/m.

(b)(c):

- the increase in the number of passing/opposing events resulted in a decrease in the LOS rank, i.e., from B to C, and lower speeds resulted in a further decrease in its rank, i.e., from C to D. The other criteria remained at the rank of A.
- in the LOS score, traffic flow conditions deteriorated in all criteria.

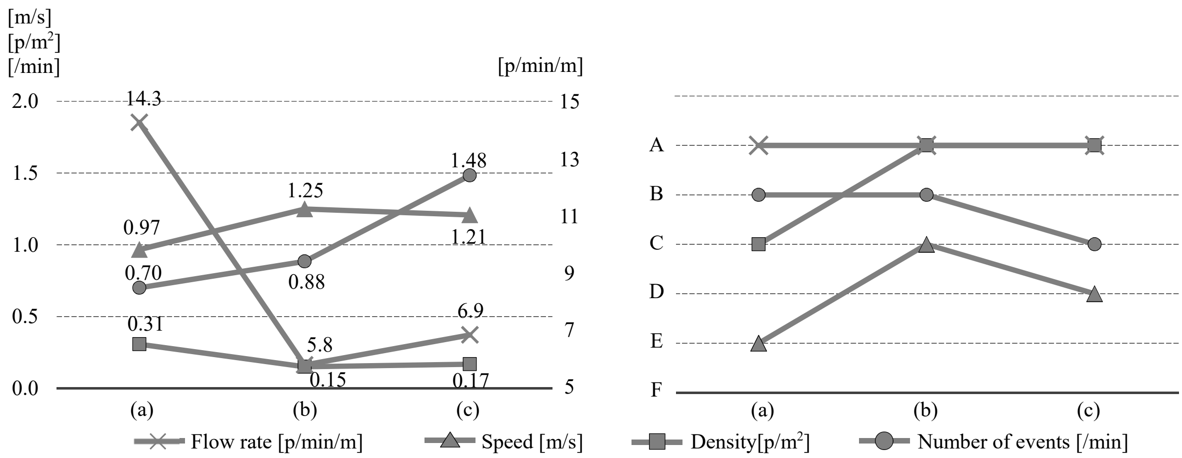


Figure 7 (Left) LOS scores, (Right) LOS rank

4. Discussion

For pedestrians from subjective comfort, they feel more comfort by installing rest spaces even if the path width narrowed. From objective comfort, however, the LOS rank and score did not improve and some criteria worsened.

Regarding the importance of factors contributing to comfortability, pedestrians feel important about the criteria included in the LOS (e.g. space, volume of pedestrians and cyclists), while not about speed; in other words, the feeling did not change by widening the path width and installing a rest space. We focused on the expected speed, but we could not confirm the change in feelings.

For cyclists from subjective comfort, they feel both comfortable and uncomfortable by installing rest spaces. The change in the traffic flow by changing path width influences on the comfort for cyclists, unlike pedestrians. The trend is also significant in the importance of factors contributing to comfortability; it can be said that there is the most comfort in section (b), since the importance is low at (b) where the path width is the widest. Regarding the expected speed, cyclists cannot surpass their expected speed step by step from (a) to (c); it is one of the factors indicating the least comfort, but it is not significant. Then, in section (a), cyclists can pass their expected speed. This was the reason why they passed the roadway at the peak time. However, we questioned cyclists who passed on the sidewalk (if they felt uncomfortable on the sidewalk, they would pass on the roadway).

5. Conclusions

This study shows that, for pedestrians, essentially for broad mixed-use spaces (as in Midosuji Boulevard, Osaka) are essentially for pedestrians and cyclists, and that there is some consistency between subjective and objective evaluations by road width widening, but there is not that by installing rest spaces. Because Due to of this, the LOS criteria from the Highway Capacity Manual cannot completely express user comfortability. For cyclists, however, traffic flow ion their passing space more influences on their comfort more than the road design, and they want to pass faster.

Further study needs to be done to improve the LOS by incorporating the effects of the rest space and the expected speed.

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