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# Meta-analysis of travel-based multitasking by railway passengers in Japan between 1983 and 2019: direct observation and YouTube videos

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## Abstract

This meta-analysis aims to analyse how the activities of rail passengers have changed in Japan as a result of rapid technological developments. To be eligible for inclusion in this analysis, source studies must have reported the number of passengers performing specific activities, and the number must have been directly counted by surveyors who actually ride on trains. Databases searched included CiNii, J-STAGE, Web of Science, and Google Scholar. References in selected studies were trialled using a snowballing method. In addition, past onboard activities were retrospectively identified by content analysis of YouTube videos in which the surveyors hypothetically travelled on a train and observed the passengers. The use of YouTube videos for meta-analysis of rail passengers' activities is a novel contribution of this study. The search for the YouTube video was entirely manual. In total, 23 independent studies with 332,355 passengers were included in the analysis. Data were collected from 1983 to 2019. The effect sizes were the proportion of each of the following activities: '(a) mobile phones', '(b) sleeping', '(c) reading', '(d) music', and '(e) other'. Meta-regressions were performed with the year of data collection as a moderator. Demonstrating historical changes in activities through statistical analysis is another novel contribution: '(a) mobile phones' and '(d) music' had a significantly increasing trend, '(c) reading' had a significantly decreasing trend, and '(b) sleeping' and '(e) other' did not change. Studies with and without YouTube videos did not affect the conclusions, which supports the use of YouTube videos for the purposes of this study. Ideas are presented for research methods that use directly observed data to explain the possible social factors behind longitudinal variation in travel-based multitasking.

**Keywords** Travel-based multitasking · Meta-analysis · Meta-regression · Direct observation · YouTube · Content analysis

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## Introduction

Travel is considered a derived demand. Few people travel for the sake of travelling. People must travel for activities at their destination, such as working in an office or studying at school. Therefore, people usually have a negative utility for the time spent travelling. Long travel distances and travel times are a serious social problem in Japan. For people living in Tokyo and its suburbs, commuting to work or school takes an extremely long time. For example, the average time to commute to and from office or school (averaged over commuters) is 107 min per day in 2016 for men living in Kanagawa Prefecture, which is adjacent to Tokyo (e-Stat 2023). These long-distance travellers primarily use rail, which allows them to enjoy a wider range of activities while commuting. Reading books and newspapers has been a popular activity, but recent technological advancements have expanded the range of activities that can be carried out while travelling (Pawlak 2020). Engaging in meaningful activities while travelling can reduce the negative utility. According to Wardman et al. (2020), the value of travel time has reportedly decreased due to the more meaningful use of travel time. This is an important factor in project evaluation (Wardman and Lyons 2016). Additionally, railway companies may invest in creating environments that promote such meaningful activities. Therefore, the present analysis is strongly linked to practice.

Keseru and Macharis (2018) strongly argued for investigating the historical changes in the onboard activities of rail passengers, but this is difficult. Few travel surveys in Japan have asked rail passengers about their onboard activities, so the authors relied on other sources of information, including academic and non-academic articles that have reported the number of passengers who were directly observed by surveyors to have engaged in activities on trains. Although this information spanned the period between 1983 and 2013, the period covered by each source was limited. Therefore, the present analysis utilises meta-analysis by combining several independent studies. Furthermore, the present analysis used YouTube videos as a data source. While observing passengers' activities in the past is impossible, it can be done retrospectively by utilising photo or video archives. The use of YouTube videos extended the period of the analysis up to 2019. Certain types of travel-based multitasking, such as the use of mobile phones, have increased over time, but looking at trends still has value. Even if some general trends are obvious, specific figures and trends are crucial for understanding the phenomenon from a statistical point of view. To the best of the authors' knowledge, no other studies have conducted a meta-analysis of rail-passenger activities. The meta-analysis in this study provides insights into previously obscure behaviours.

The main interest of this study is to demonstrate whether a particular perception is valid: *People feel something was true in the past, but it is no longer true.* For the example of car ownership, this statement is translated as follows: People feel that car ownership was low in the past, but it is high now. People's feelings about car ownership can be expressed as a proportion of car ownership (e.g., the number of cars per household or per head). Past and present express the passage of time. It is, therefore, natural to try to explain the proportion of car ownership by the passage of time (e.g., years). In the context of the present study, people feel that travel-based multitasking in Japan was like 'that' in the past, but it is like 'this' now. Therefore, an attempt is made to explain the percentage of passengers engaged in each type of travel-based multitasking by the years. Factors affecting the choice of travel-based multitasking (socio-economics and trip characteristics) are of interest for researchers, including the present authors. Although not the main interest of the present study, ideas also

are presented for research methods that use directly observed data to explain the possible social factors behind longitudinal variation in travel-based multitasking.

The rest of this paper is structured as follows. The “[Background](#)” Section presents the background of the study. The “[Methodology](#)” Section describes the methods, and the “[Results](#)” Section reports the results and the abovementioned ideas. Finally, the “[Discussion and conclusions](#)” Section discusses the results and ideas with reference to two longitudinal studies and presents the conclusions.

## Background

This section discusses some important topics relating to the present analysis with reference to previous studies. The “[Questionnaires versus direct observation](#)” Section discusses the data collection methods and explains why the present analysis uses data collected only through direct observation. The “[Longitudinal studies](#)” Section reviews studies that have analysed travel-based multitasking over the years. The “[YouTube videos as retrospective direct observation](#)” Section reviews literature that used photo or video archives to retrospectively observe events in the past. The “[Some historical events relating to onboard activities in Japanese railways](#)” Section reviews historical events that are closely related to travel-based multitasking by rail passengers in Japan.

### Questionnaires versus direct observation

Two of the most commonly used data collection methods for travel-based multitasking are questionnaires and direct observation (Keseru and Macharis 2018).<sup>1</sup> The questionnaire method asks respondents to report their activities while travelling, while the direct observation method places a person on board a train to observe and record the activities of the passengers. Cost-effectiveness in data collection is a huge advantage for the questionnaire method, while direct observations incur huge costs in both time and money.

Table 1 contrasts the two methods. Direct observation has three advantages. First, the observed activities are similar across studies. This is a benefit that derives from the fact that the surveyors assess the activities with their own eyes. To ensure consistent data collection, the surveyors are given criteria for activity registration. This is beneficial compared to questionnaires, in which respondents register their activities based on their own criteria. For example, if a passenger has their eyes closed, an observer cannot determine if the passenger is sleeping, thinking, or doing nothing. Therefore, the observer must register the passenger as ‘sleeping’, which is a criterion usually adopted. A careful review of the literature collected for the present meta-analysis shows that the classification of activities is similar across studies. This is likely due to the fact that the observers show little difference in their ability to identify the types of activities. On the other hand, questionnaires can include as many activities as interest the researchers, resulting in marked differences in the types of activities reported across studies.<sup>2</sup>

<sup>1</sup> Another important source of data is the in-depth interview. In the sense that they are not directly observed by a third party, in-depth interviews are closer to questionnaire surveys than to direct observation.

<sup>2</sup> Analysing travel-based multitasking using data collected by different methods is more difficult. Russell (2012) compared percentages of travel-based multitasking reported in six studies (two observations and four

**Table 1** Differences between questionnaire and direct observation surveys

	Questionnaire	Direct observation
Definition	<ul style="list-style-type: none"> <li>• Ask respondents to report their onboard activities</li> </ul>	<ul style="list-style-type: none"> <li>• Third party rides train, observes passengers, and records their activities</li> </ul>
Cost	<ul style="list-style-type: none"> <li>• Less expensive</li> </ul>	<ul style="list-style-type: none"> <li>• Expensive in both time and money</li> </ul>
Surveyed Activities	<ul style="list-style-type: none"> <li>• All activities that interest the researchers</li> <li>• Respondents know exact activities</li> <li>• Activities can differ across studies</li> </ul>	<ul style="list-style-type: none"> <li>• Limited to activities that can be identified by third-party observation</li> <li>• Activities are inferred by surveyors</li> <li>• Few differences across studies</li> </ul>
Timing	<ul style="list-style-type: none"> <li>• Asking about activities in real time is difficult</li> <li>• Common to ask respondents to report activities after the journey</li> <li>• Respondents report either multiple activities conducted at any time or a single activity conducted most of the time</li> </ul>	<ul style="list-style-type: none"> <li>• Real time</li> </ul>
Aggregation	<ul style="list-style-type: none"> <li>• Difficult to develop consistent classification</li> <li>• Problem of double-counting when multiple responses are allowed</li> </ul>	<ul style="list-style-type: none"> <li>• Not an issue</li> </ul>

The second advantage of direct observation is it ensures that an activity actually occurred, and usually, only one activity is recorded per passenger. This is not always true in questionnaires since respondents are asked to report their activities retrospectively, and they do not always remember what they did at a particular moment (e.g., 9:01:01 this morning). To rectify this problem with human memory, Clayton et al. (2017) asked bus passengers about their current activities on the bus. However, this method is rarely adopted. Therefore, questionnaires can only ask respondents about their activities during the entire journey, with respondents ticking off either all of the activities that were conducted at any time during the journey or one activity that was conducted most of the time. Allowing multiple choices, however, results in the problem of aggregation.

This is the third advantage of direct observation: it is free from the problem of aggregation since activities are similar across studies, and only one activity is registered per respondent. This is very different from questionnaires, which include all of the activities that interest the researchers and allow respondents to report multiple activities. Consistent activity classification is essential for inter-study comparison, but this is not easy to do. For example, one study may classify reading as ‘reading (newspapers)’ and ‘reading (books)’, while another study classifies it as ‘reading’. The broader classification of ‘reading’ is usually adopted, but when multiple responses are allowed, adding together the numbers for ‘reading (newspapers)’ and ‘reading (books)’ results in double-counting.

In addition to these three advantages, direct observation also has the potential advantage of better representativeness of the population of interest. Random sampling, in which everyone in the population has an equal chance of being selected as a respondent, is generally thought to be ideal. For the present analysis, however, this representativeness may not be suitable. Respondents differ in the frequency of their train use and the length of their jour-

questionnaire surveys) and stated that they vary considerably across studies. The only exception is Russell (2012), who carefully designed the two data collection methods and demonstrated comparable percentages in travel-based multitasking between structural observations and questionnaire surveys.

neys, and the activities undertaken by these respondents likely differ from those observed on randomly selected trains at randomly selected moments. In direct observation, surveyors are asked to report on the activities of the passengers around them, and the passengers around them are the respondents. The representativeness of direct observation varies from survey to survey. In some studies, volunteers are recruited to report their observations of passengers on trains that they use daily. Other studies focus on specific railway lines and make the same number of direct observations on each line. While representativeness is not a main topic of the present analysis, when achieved through direct observation, representativeness differs across survey protocols, but it is likely to be similar to observations on randomly selected trains at randomly selected moments.

## Longitudinal studies

Travel-based multitasking by rail passengers has a long history of interest, but historical trends in multitasking have rarely been studied. Lyons et al. (2013) examined data from the British National Rail Passenger Survey between the years 2004 and 2010, while Lyons et al. (2016) expanded the analysis to include data from 2014, a span of 10 years. The two studies compared how passengers used in-vehicle time for each trip purpose. In Japan, Sanko (2023) investigated travel-based multitasking using data from 2001, 2006, 2011, and 2016, covering a span of 15 years. The data came from Questionnaire B of the Japanese Surveys on Time Use and Leisure Activities. Questionnaire B asked for primary and secondary activities in 15-minute time slots, with travel-based multitasking identified by time slots where the primary and secondary activities involved travelling and other activities, respectively. However, the transportation modes used were unknown.

In the extensive review of the literature for the present analysis, some studies were found that collected data via direct observations from various time points. For example, a research group led by Itoga conducted direct observations every year between 2004 and 2013 (Osada et al. 2014). Kataoka et al. (2002) compared the activities of rail passengers in Tokyo in 1987, 1997, and 1999. The Shuppan Forum published a special article focusing on reading by rail passengers. Direct observation was carried out at five points in time: 1986, 1988, 1997, 2004, and 2007 (Shuppan Forum 1986, 1988, 1997, 2004, 2007). These studies are useful for drawing more concrete conclusions and are included in the meta-analysis below.

## YouTube videos as retrospective direct observation

While the activities of passengers in the past cannot be directly observed, activities can be observed retrospectively by utilising archived photos and videos. Such photos and videos would be a snapshot or series of snapshots taken when a surveyor was hypothetically on the train at the time. However, photos and videos are not usually taken to record the daily activities of passengers. As a result, the authors found very few photos and videos in books, newspapers, videos, and their archives that met the aims of the present analysis. YouTube videos, however, did meet the aims.<sup>3</sup> Established in 2005, YouTube has become popular worldwide. According to a survey of 1500 people aged 13–69 by MIAT (2023), YouTube is the most popular video-sharing service in any age group in Japan. In 2022, more than 90%

<sup>3</sup> Although not done in this study, it is also possible to estimate duration of travel by watching YouTube videos.

of people aged 13–49 watched YouTube videos, while 87% and 68% of people 50–59 years old and 60–69 years old, respectively, did so. Although YouTube videos may not be representative, they were a valuable source of data for the present analysis.

Some transport researchers have used archival data as a data source. Gruber et al. (2018) used photographic archives to understand changes in street use and street design in Vienna, Austria, between 1860 and 1949. YouTube videos have been increasingly used as a source of information in research (Mostafa et al. 2023). In a transportation study, Seeley et al. (2019) used 65 YouTube videos of street racing, stunt driving, and ghost driving and examined the content of the videos. However, using YouTube videos as a retrospective data source is less common due to the relatively short history of the service. While videos taken earlier than 2005 are available, they are relatively rare.

### Some historical events relating to onboard activities in Japanese railways

The first railway in Japan opened in 1872 between Shimbashi and Yokohama, a distance of 29 km. The railway network subsequently expanded rapidly. This section describes some historical events related to passenger activities on trains.

Reading has been one of the most popular activities on trains. Nagamine (2004), whose main interest is Japan's reading culture between 1897 and 1906, describes the reading behaviour of railway passengers at the beginning of railway service. Reading was already a popular activity in railway carriages. However, reading habits differed from person to person. It was common to read aloud, which annoyed other passengers and caused conflicts. The change in Japanese reading habits to silent reading is partly a consequence of these conflicts. Businesses that facilitated reading on board trains were established. In 1897, rental bookshops were opened at major stations, and passengers could borrow books and return them to any of the bookshops operated by the same company. In 1911, a railway library (a bookshelf) was installed in the first- and second-class carriages of express trains. Reading materials have traditionally been paper-based. In recent years, reading materials have taken many different forms, such as portable electronic devices.

Activities other than reading also became popular as a result of new technologies. Many of these technologies created new types of conflicts among passengers. For example, portable audio players were introduced around 1980, which made it possible to listen to music on trains. However, sound leaking from earphones annoyed other passengers. Mobile phones, with their loud ring tones and users' loud voices during calls, also caused conflicts. Train operators have struggled to develop rules of social conduct. In September 2003, 17 train operators in the Tokyo area agreed to publish the same request to passengers regarding mobile phone etiquette: switch off the phone near priority seats and in other places use the silent mode and not talk (East Japan Railway Company 2003). Since October 2015, switching off while near priority seats has only been requested when trains are crowded (East Japan Railway Company 2015). Some activities that were allowed in the past are now prohibited. East Japan Railway Company's local trains became completely smoke-free in 1997 (East Japan Railway Company 2023). Since then, there has been a growing trend to prohibit smoking in train carriages and stations. Controversial in-vehicle behaviours have been revealed in the results of surveys asking about annoying behaviours in trains and in letters to newspapers. Examples include putting on makeup and eating.

## Methodology

The literature review was conducted and reported following the PRISMA statement (Page et al. 2021). The review was not registered in any public database, since the protocol had not yet been developed at the start of the present analysis. Ethical approval was not required, as the data used in the study were publicly available.

### Search strategy and eligibility criteria

A comprehensive literature search was conducted using the CiNii, J-STAGE, and Web of Science databases. This was supplemented by a manual search using Google Scholar. An example of the search strategy can be found in Supplementary Table 1. The eligibility of an article was assessed based on the title and abstract; if eligibility could not be determined from the title and abstract, the full text was used for assessment. Also conducted was a snowball search of studies listed in the references of articles that had passed the eligibility check. The search for YouTube videos was entirely manual.

The meta-analysis included studies that met all of the following criteria: (1) subjects were rail passengers on Japanese railways; (2) passengers in reserved seats were excluded; (3) activity counts were included; (4) at least ten passengers were surveyed; (5) studies were conducted before and during 2019 (before the spread of COVID-19); and (6) studies were in English or Japanese.

The literature searches and counts for academic and non-academic journals were carried out by one author (SY) in 2022 and early 2023, while the data searches and counts for YouTube videos were carried out in 2019 and 2020 by a person mentioned in the Acknowledgements section under the supervision of one author (NS). One author (NS) reviewed both datasets and made the final decision in August and September 2023.

### Data extraction

The number of times each activity was conducted and the year of data collection were extracted. Also noted were the respondents' socio-economic attributes, which were used in the descriptive analysis in the “Study characteristics” Section, but not in the meta-analysis. Classifications of activities differ across studies, and even independent studies by the same research group may use different classifications based on their previous experience or on activities that have emerged due to technological developments. After careful consideration, the following five classifications were adopted: ‘(a) mobile phones’, ‘(b) sleeping’, ‘(c) reading’, ‘(d) music’, and ‘(e) other’. Some studies have finer classifications, but they have been grouped into the above five classifications. Note that ‘(c) reading’ is further divided into subclasses: ‘(c1) newspapers’, ‘(c2) books’, and ‘(c3) magazines and comics’.

The procedure used for extracting data from a YouTube video is described. In each video, the activities of each passenger were counted. The count was done for a single scene per video to avoid double-counting. The choice of scene was based on the ease of counting, i.e., a scene in which a smaller number of standing passengers and a larger number of seated passengers were observed. The activities were identified in the order of passengers closest to the camera to passengers farthest from the camera; identification was stopped when a passenger whose activity could not be identified appeared. In many cases, the process of



identification stopped when seated passengers were hidden from the camera by other seated passengers. Passengers in more distant positions were not included, even if their activities were identifiable. As the activities of passengers in hidden positions would be easily identifiable if the onboard surveyors changed their viewpoint, the inclusion of passengers only in distant positions differs from the practice of direct observation. The content analysis here was designed to avoid arbitrary selection of passengers. The time of their recording was not considered to be the time of upload, as older videos may have been uploaded later. Rather, the time of their recording was determined from notes in the description section of the video or by clues (e.g., advertisements) recorded as part of the video.

## Statistical analyses

R was used to conduct meta-analyses for percentages of travel-based multitasking (R Core Team 2023; Wang 2018). The percentages of passengers who performed activities were the effect size measure. A meta-analysis can be either fixed-effects or random-effects models. The fixed-effects model is used when groups of studies are to be combined under almost homogeneous circumstances using exactly the same methods, while the random-effects model is used when groups of studies are to be combined, each with different study qualities and methods (Borenstein et al. 2021). In this paper, the data include studies conducted by different researchers for different purposes. Therefore, the random-effects model was adopted. Logit transformation was performed, with continuity correction by adding 0.5 as zero frequencies. Each study was weighted by the inverse-variance method. The between-studies variance ( $\tau^2$ ) was calculated using the DerSimonian and Laird method, and its confidence interval was calculated using the Jackson method. For the purpose of reference, this study presents  $I^2$  (the ratio of true heterogeneity to total observed variation) and Cochran's  $Q$ -test ( $\chi^2$  values) (a measure of weighted squared deviations).

Publication bias is not an issue in the present analysis. Activities were classified as (a)–(e), and all classifications were used in the meta-analysis. The sum of the proportions for classifications (a)–(e) is unity. Therefore, the deliberate selection of studies reporting a higher proportion for one activity leads directly to the deliberate selection of studies reporting a lower proportion for another activity. As the aims of the surveys differ across studies, it is unlikely that certain behaviours are over-reported. Publication bias should be assessed from a qualitative perspective. Barker et al. (2021) mentioned that no definition or consensus was made regarding a positive result in the proportional meta-analysis. Therefore, Egger's test, Begg's test, and funnel plots were not appropriate. However, for the purpose of reference, this study presents funnel plots.

Subgroup analyses were a suitable methodology for dividing all studies into subgroups, where the studies in each subgroup were homogeneous. However, the present analysis does not have such a factor, and no subgroup analyses were conducted. Meta-regression is a method for quantitatively analysing the degree to which the dependent variable can be explained as explanatory variables that are thought to create heterogeneity in individual studies (Borenstein et al. 2021). A univariate meta-regression was performed with the survey year (not the publication year but the year of data collection) as an explanatory variable. The year of the survey as the moderator is an obvious choice for examining how travel-based multitasking has changed over time. One possible concern is that the factors behind the trends over time are unknown. Although not the main aim of this study, the authors

attempted to explain travel-based multitasking using other moderators that reflect the social trends of the time.

## Results

### Study characteristics

The PRISMA flow diagram in Fig. 1 shows how the studies were selected, with comprehensive searches carried out in the following databases: CiNii (158 hits), J-STAGE (5268 hits), and Web of Science (25 hits).

First, all titles and abstracts were screened against the inclusion criteria. This strategy eliminated 5435 irrelevant studies. Second, the full texts of the remaining 16 studies that appeared to meet the inclusion criteria were assessed. Of these, one met the inclusion criteria and was included in the meta-analysis, while 15 were excluded for the following reasons: 11 studies did not include direct observation, three studies conducted direct observation but did not report counts, and one study (Ohmori and Harata 2008) included passengers in reserved seats. In addition, a manual search using Google Scholar identified one study. Finally, a snowball search for studies listed in references identified eight studies. Some articles include observations from multiple time points, and data from different time points were considered to be different observations. The ten articles included 21 independent studies. Where multiple independent survey results were reported in one article, each result was referred to as an independent study to avoid confusion.

YouTube videos were regarded as a single data source, so Fig. 1 mentions ‘N=1’. Eighteen videos were identified from the years 2005, 2009, 2016, 2017, 2018, and 2019. After manually identifying activities and applying the eligibility criterion of having at least ten

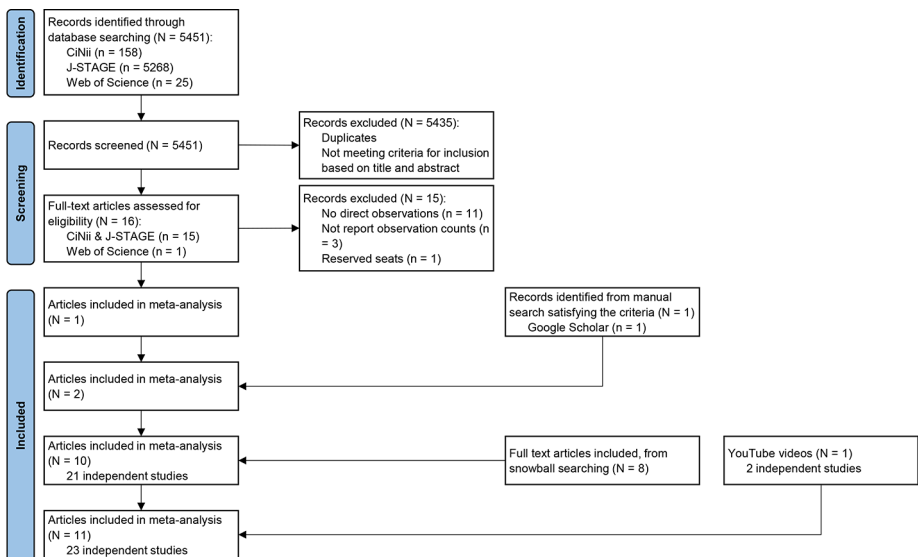


Fig. 1 PRISMA diagram

passengers, only data from the years 2016 and 2019, consisting of 12 videos, passed the eligibility criteria. Therefore, YouTube videos comprised two independent studies.

Table 2 summarises the studies included in the meta-analysis. The review identified 23 independent studies from 11 sources. All but one publication study reported data from the Tokyo metropolis. The exception was Harada et al. (2014), which was from the Osaka metropolis. Although Shuppan Forum (2007) did not specify the study area, the data likely was from Tokyo due to the survey's continuity. Most of the surveys were conducted by university researchers with support from their students, whereas the Shuppan Forum used volunteers for data collection. Both standing and seated passengers were observed except for Kataoka et al. (2002), who observed only seated passengers. Research interests differed across the studies: group (1) investigated passenger activities (Kataoka et al. 2002; Harada

**Table 2** Studies included in meta-analysis

Authors (Year)	a) Dates of observation b) Criteria of observation
Osada et al. (2014)	a) Mid-Oct. to Mid-Nov. (every year between 2004 and 2013) b) Four railway lines in the Tokyo metropolis Local trains Weekdays, 10:00–12:00 and 17:00–19:00 Excluded sections close to terminal stations Excluded rainy days and special occasions (e.g., study tours) Recorded multiple activities per passenger, but at most 11.7% of passengers engaged in two or more activities
Shuppan Forum (1986, 1988, 1997, 2004, 2007)	a) 1986: 2 Oct. to 8 Oct. 1988: 12 Oct. to 18 Oct., excl. 16 Oct. 1997: 25 Sept. to 3 Oct. 2004: 21 Oct. to 28 Oct. 2007: 24 Oct. to 31 Oct. b) Commuting trains in the Tokyo metropolis (Survey area for 2007 survey not explicitly mentioned, but likely the same survey area as defined in previous surveys)
Kataoka et al. (2002)	a) 1999: 27 Sept. to 31 Oct. (Surveys also conducted in 1997 and 1987, but without specific dates) b) Seated passengers on trains in the Tokyo metropolis 10:00–19:00 Excluded Saturdays, Sundays, national holidays, and rainy days Excluded passengers with accompanying persons
Aikyou (1984)	a) 1983: Summer b) Not specified. Many observations were probably from Tokyo, since surveyors were students located in Tokyo.
Yada (1993)	a) 1992: May and June (Year not mentioned, but paper received in Sept. 1992) b) Tokyu Toyoko line in Tokyo metropolis
Harada et al. (2014)	a) 2013: 21 Oct. to 13 Nov. b) Four railway lines in the Osaka metropolis Local trains (also Hankyu Semi-rapid) Weekdays, 10:00–12:00 and 17:00–19:00 Excluded sections close to terminal stations Excluded rainy days and special occasions (e.g., study tours) Recorded multiple activities per passenger, but at most 9.6% of passengers engaged in two or more activities
YouTube	a) 2016, 2019 b) Japan Activities identified in order of person closest to the camera to furthest from camera Observation terminated when passenger with unidentifiable activity appeared Excluded passengers with identifiable activities at more distant locations due to the risk of including too much data on easily identifiable activities

et al. 2014; Osada et al. 2014), whereas group (2) focused on passenger reading habits (Shuppan Forum 1986, 1988, 1997, 2004, 2007; Aikyou 1984; Yada 1993). However, the studies in group (2) also reported non-reading activities, as did the studies in group (1). The YouTube group included two independent studies, and the data are from all of Japan.

Several studies have collected passengers' socio-economics data in order to understand the relationships between activity types and socio-economics. The data collected include gender, age group, posture (seated/standing), time of day, day of week, and railway line. Surveyors subjectively determined the gender and age group of the passengers. Some findings obtained from the Shuppan Forum are noteworthy regarding the relationship between reading materials and socio-economic status. Newspapers are more likely to be read by older males, although this tendency has weakened in recent years. Books are more likely to be read by females, while magazines are more likely to be read by younger males. In terms of time of day, newspapers usually are read in the morning, while books and magazines are read in the evening. Electronic devices are used more often at night. In the case of weekly magazines, a relationship was noted between reading material (media) and the day of the week of publication.

## Meta-analysis

Table 3 presents the number of counts for each activity included in each independent study used for the meta-analysis. The published studies were sorted by the number of independent studies (largest number to smallest number), followed by the YouTube videos. As mentioned in the “[Questionnaires versus direct observation](#)” Section, only one activity per passenger usually is recorded. Not all studies mention the protocol for selecting a single activity when surveyors must choose from more than one activity; some studies explicitly stated that surveyors should only select a single activity that appears to have more weight. Some studies allowed surveyors to report more than one activity per passenger. However, this is a minor concern as, at most, only 12% of passengers had more than one activity. Some studies included typographical errors in the figures due to unknown reasons. However, the errors were minor, and the figures are used as is. The dataset has 11 sources (ten articles and one YouTube) with 23 independent studies from 332,355 passengers. Since the five classifications were not always examined in each independent study, the number of independent studies included in the meta-analysis differs for each activity classification. Activities included in ‘(e) other’ may not be directly comparable since some independent studies record parts of (a)–(d). Analysis for ‘(e) other’ is limited to independent studies that have all four (a)–(d) classes. However, this does not apply to independent studies without ‘(a) mobile phones’ in Shuppan Forum (1988) when data is collected from a time before mobile phones became widespread. The number of included independent studies ranged from 17 for ‘(e) other’ to 23 for ‘(c) reading’. The activities defined in each independent study were grouped as outlined in Supplementary Table 2.

Activity types examined were: ‘(a) mobile phones’, ‘(b) sleeping’, ‘(c) reading’, ‘(d) music’, and ‘(e) other’. ‘(c) reading’ was further classified into ‘(c1) newspapers’, ‘(c2) books’, and ‘(c3) magazines and comics’. Supplementary Fig. 1 presents forest plots. The pooled estimates and 95% CI were: 15.22% (95% CI 11.86–19.32%) for ‘(a) mobile phones’, 14.20% (95% CI 12.83–15.68%) for ‘(b) sleeping’, 17.70% (95% CI 14.88–20.91%) for ‘(c) reading’, 6.97% (95% CI 5.71–8.48%) for ‘(d) music’, 45.45% (95% CI 41.63–49.32%)

**Table 3** Datasets-activity counts

No.	Authors (Year)	Year data collected	(a) mobile phones	(b) sleeping	(c) reading	(d) music	(e) other	(c1) newspapers	(c2) books	(c3) magazines, comics	n (Total number of passengers)
1	Osada et al. (2014)	2004	2606	2549	4135	1022	11,427	1313	1944	878	21,209
2		2005	2468	3068	3143	1572	11,743	777	1624	742	21,216
3		2006	2683	3502	3427	1803	11,886	646	2005	776	22,174
4		2007	3391	2953	2979	2009	11,456	592	1785	602	21,414
5		2008	1135	939	1004	781	3612	190	643	171	6953
6		2009	3833	2678	2763	1805	10,094	518	1742	503	20,873
7		2010	5035	2753	2567	2606	9911	403	1713	451	21,441
8		2011	5491	2949	2407	2938	9902	318	1664	425	21,659
9		2012	6345	2541	2351	3189	9357	470	1563	318	21,828
10		2013	8463	2681	1910	3337	8853	261	1371	278	22,590
11	Shuppan Forum (1986)	1986	X	1397	2990	X	X	1010	1117	863	11,541
12	Shuppan Forum (1988)	1988	X	1282	2129	209	3844	800	814	515	7464
13	Shuppan Forum (1997)	1997	343	1933	3040	412	4350	890	1101	1049	10,078
14	Shuppan Forum (2004)	2004	1437	2922	3517	700	6043	985	1761	771	14,619
15	Shuppan Forum (2007)	2007	2711	3333	4378	1231	3574	1300	2392	686	15,227
16	Kataoka et al. (2002)	1987	X	X	1851	206	X	529	694	628	7820
17		1997	77	X	1206	156	X	279	493	434	5602
18		1999	370	X	2059	343	X	463	917	679	8817
19	Aikyou (1984)	1983	X	X	3435	X	X	1439	1034	1111	10,886
20	Yada (1993)	1992	X	2145	4388	X	X	X	X	X	20,172
21	Harada et al. (2014)	2013	5817	2401	1643	2293	8304	266	1146	231	18,687
22	YouTube	2016	22	9	9	2	28	1	7	1	70
23		2019	10	2	0	1	2	0	0	0	15

Note: Cells with 'X' were not used for the analysis. Some studies allowed surveyors to record more than one activity per passenger. Typos were included in the data source; these were used as-is. The column labelled 'No.' indicates the independent study number used throughout this paper

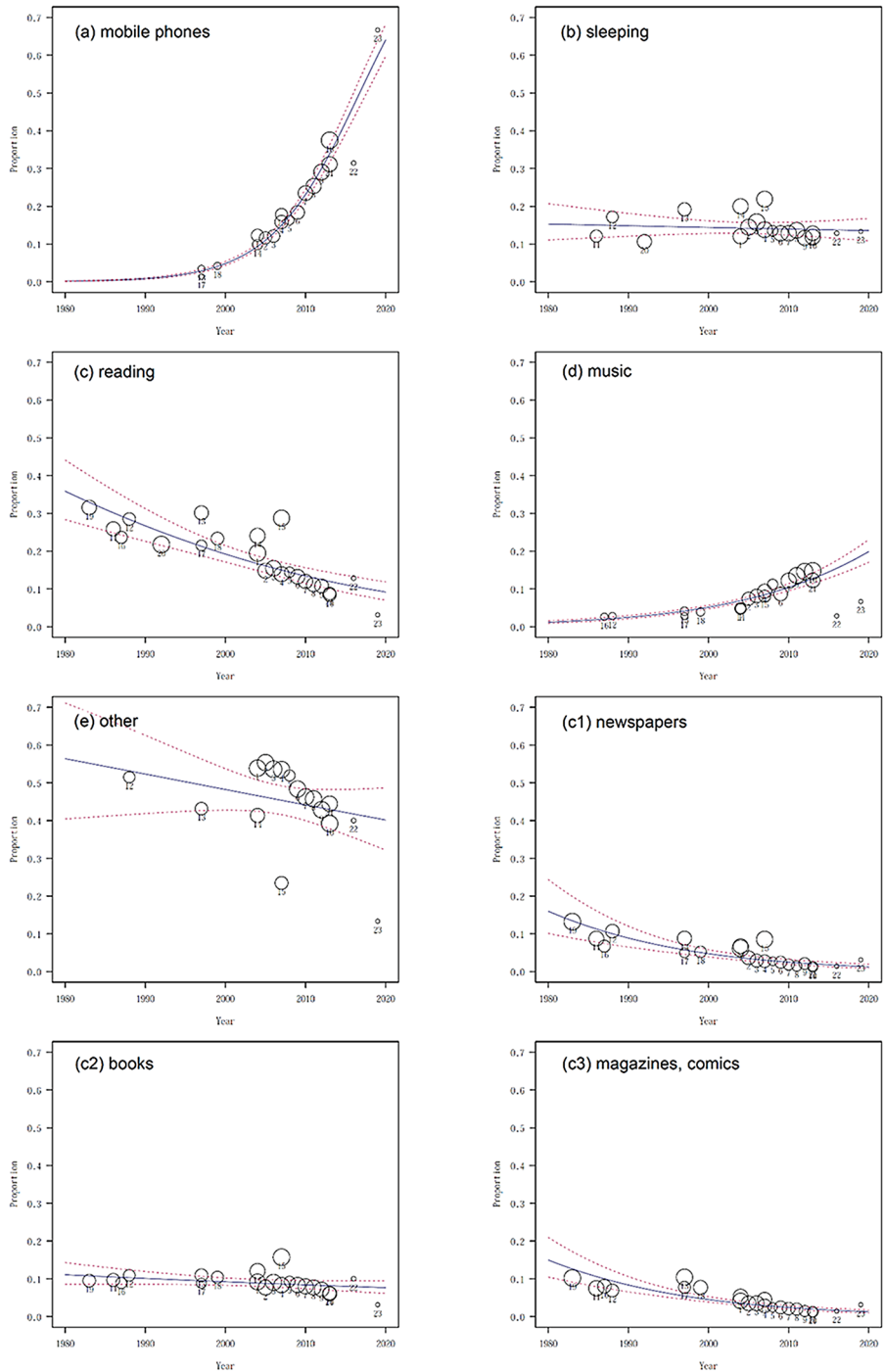
for ‘(e) other’, 4.01% (95% CI 2.97–5.41%) for ‘(c1) newspapers’, 8.99% (95% CI 8.07–10.00%) for ‘(c2) books’, and 3.82% (95% CI 2.88–5.04%) for ‘(c3) magazines and comics’. In all eight classifications,  $I^2$  (the ratio of true heterogeneity to total observed variation) was greater than or equal to 99%, and Cochran’s  $Q$ -test ( $\chi^2$  values) (a measure of weighted squared deviations) of heterogeneity demonstrated a lack of homogeneity among the studies ( $p < 0.0001$ ). For the purpose of reference, the funnel plots in Supplementary Fig. 2 indicated no clear publication bias. The funnel plots include a line of summary effect and pseudo 95% confidence limits. Scatter plots were generated in Fig. 2 with a solid regression line and two dotted lines showing the corresponding 95% confidence interval bounds. The size of the bubble represents the weight of the studies. Numeric labels attached to each bubble correspond to the number (‘No.’) representing each independent study shown in Table 3. The regression results also are presented in Table 4.

The percentages of passengers engaging in activities utilising ‘(a) mobile phones’ and ‘(d) music’ showed increasing trends with statistical significance. On the other hand, the percentage of ‘(c) reading’ has decreased over the years with statistical significance. The percentages of ‘(b) sleeping’ and ‘(e) other’ were stable and did not change with any reasonable level of statistical significance. Among the (c) subcategories, ‘(c1) newspapers’ and ‘(c3) magazines and comics’ showed a statistically significant decreasing trend over time. The temporal evolution of rail passengers’ travel-based multitasking has never been statistically analysed using direct-observation data, and the results presented here are unique. Estimates with respect to the signs and level of statistical significance presented in Table 4 did not change when the independent studies from YouTube were excluded. The results support the use of YouTube for the purposes of this study, as the inclusion of YouTube data did not interfere with the results. Although the small sample size of YouTube data may also have been a reason, note that the random effects model is characterised by the relatively large weights given to studies with small sample sizes (compared to fixed effects models) for analysis (Borenstein et al. 2021).

However, the meta-analysis in the present analysis does not consider the socio-economic status of passengers. This is because only a small number of independent studies (fewer than 10) reported the number of activities for each socio-economic status. The meta-analysis was performed separately for men and women since the gender attribute provided the largest number of independent studies and so was the most appropriate choice for sub-group analysis. The results were slightly different from those based on the full data sets in some parts, but the authors have chosen not to report them. This might be misleading because of the smaller number of independent studies included and the much shorter time span of the data used.

## An extension

Data collected by direct observation is potentially useful for investigating social trends that influence travel-based multitasking. As the socio-economic attributes collected through direct observation are limited, questionnaire surveys and in-depth interviews are more appropriate for a deeper understanding of socio-economics. However, as mentioned in Table 1, data collected by questionnaire surveys and in-depth interviews are rarely comparable across time points, and analysis using these data collection methods must rely on data from a single time point. Exceptions are Lyons et al. (2016) and Sanko (2023), which



**Fig. 2** Meta-regression scatter plot using data year as moderator

Note: The numbers next to the bubbles are the 'No.' mentioned in Table 3

**Table 4** Meta-regression using data year as moderator

Variables	(a) mobile phones	(b) sleeping	(c) reading	(d) music	(e) other	(c1) newspapers	(c2) books	(c3) magazines, comics
Intercept	-358.9520 *** (13.5977)	5.2469 (14.6001)	84.0685 *** (14.6410)	-154.4890 *** (11.3017)	32.7117 (23.9584)	130.8417 *** (22.0673)	18.1330 (12.2092)	128.7665 *** (17.2405)
Year	0.1780 *** (0.0068)	-0.0035 (0.0073)	-0.0428 *** (0.0073)	0.0758 *** (0.0056)	-0.0164 (0.0119)	-0.0669 *** (0.0110)	-0.0102 † (0.0061)	-0.0659 *** (0.0086)
<i>n</i>	18	19	23	20	17	22	22	22
<i>R</i> <sup>2</sup>	95.50%	0.00%	57.01%	85.99%	2.34%	58.20%	8.82%	70.74%

Note: Standard errors in parentheses. \*\*\*  $p < 0.001$ , \*\*  $p < 0.01$ , \*  $p < 0.05$ , †  $p < 0.1$



are discussed in the “[Discussion and conclusions](#)” Section. Data from a single time point express differences among respondents, which also is important, but do not explain changes of activities over time (Kitamura 2003). Since data at a single time point have limited variations in some variables, such as mobile phone penetration and the availability of internet access, such data cannot be used to analyse the impact of factors that may change over time in a society as a whole. On the other hand, direct observation data collected from multiple time points have variations in variables that change over time in a society as a whole. Methods to improve forecasts by using cross-sectional data from multiple time points—also known as the updating function model—are proposed by Sanko (2014, 2016, 2018, 2022), which express parameters as functions of social trends, such as gross domestic product per capita.

Another direction of study is building a meta-model using factors expressing the social trends of the times as moderators to forecast the future. For comparison, the analysis is repeated when the moderator variable of ‘year’ is replaced by one of the following variables: fixed broadband subscriptions (per 100 people), mobile cellular subscriptions (per 100 people), and individuals using the Internet (% of population). The estimates for the moderator in Table 4 did not change in terms of sign and level of statistical significance (five per cent). This is because the correlation coefficients are close to unity: 0.929 between year and fixed broadband subscriptions (per 100 people), 0.980 between year and mobile cellular subscriptions (per 100 people), and 0.958 between year and individuals using the Internet (% of population) using 37 data points between 1983 and 2019. As an example, mobile cellular subscriptions (per 100 people) as a moderator is presented in Supplementary Fig. 3 for bubble plots and Supplementary Table 3 for meta-regressions.

## Discussion and conclusions

This was the first analysis of the long-term changes in travel-based multitasking by rail passengers in Japan. The data were collected from direct observations published in both academic and non-academic articles and from content analysis of YouTube videos. In terms of results, no other relevant studies can compare with this study. However, two studies have reported results from multiple time points. These studies are useful for the following discussion.

The first study, Lyons et al. (2016), analysed the National Rail Passengers Survey for Great Britain in 2004, 2010, and 2014. While the analysis of the rail passengers is the same as the present meta-analysis, both the location of the study in Great Britain and the questionnaire method used for data collection differ from the present meta-analysis. Respondents who were about to board trains at stations received questionnaires and were asked to report any activities and on which activity they spent the most time. Table 5 summarises the results of this study using a slightly different presentation. There is no one-to-one correspondence between the classifications used in Lyons et al. (2016) and those used in the present meta-analysis. However, if the activities in Table 5 were re-classified using the (a)–(e) classifications of the present meta-analysis (noted in front of the names of the activities), then the following interpretations can be made. ‘Working/studying (reading/writing/thinking)’ in Lyons et al. (2016) was self-reported and the form it took is unclear; it could include any of (a)–(e) as defined in this study: ‘(a) mobile phones’ when writing emails for work,

**Table 5** Results of Lyons et al. (2016): activities conducted by passengers at any time or most of the time while on the train (% of respondents in each autumn survey for all purposes)

Activities	Any time						Most time					
	2004	2010	2014	i	ii	iii	2004	2010	i	ii	iii	
(a) Watching a film/video	N/A	1.6	2.6		+		N/A	0.5		1.3	+	
(a) Text messages/phone calls - work	8.2	14.4	12.8	+	-	±	0.6	1.2	+	1.2		±
(a) Text messages/phone calls - personal	18.7	28.6	27.6	+	-	±	1.0	2.0	+	2.8	+	±
(a) Checking emails	N/A	16.1	25.1		+		N/A	2.2		3.5	+	
(a) Internet browsing	N/A	9.3	18.0		+		N/A	0.8		2.7	+	
(a) Accessing social networking sites	N/A	5.8	12.2		+		N/A	0.5		1.4	+	
(a) Playing games (electronic or otherwise)	1.6	3.9	4.5	+	+	±	0.3	0.9	+	1.5	+	±
(b) Sleeping/snoozing	14.6	13.0	10.1	-	-	-	3.7	3.5		2.8	-	-
(c) Reading for leisure	53.7	50.2	40.5	-	-	-	37.9	37.0		32.6	-	-
(d) Listening to music/radio/podcast	9.0	19.0	14.6	+	-	±	3.7	8.6	+	6.8	-	±
(e) Working/studying (reading/writing/thinking)	25.5	25.3	21.2		-	-	14.5	13.7		12.4	-	-
(e) Talking to other passengers	15.5	13.1	11.6	-	-	-	6.7	5.2	-	6.8	+	
(e) Window gazing/people watching	57.1	49.2	43.7	-	-	-	20.4	19.0	-	18.6		-
(e) Eating/drinking	14.9	15.8	13.0	+	-	-	0.3	0.5	+	0.6	±	
(e) Caring for someone travelling with you (including children)	2.2	2.3	2.1				1.3	1.3		1.3		
(e) Being bored	12.0	9.8	8.4	-	-	-	1.9	1.6		2.1	+	
(e) Being anxious about the journey (e.g., delays or where to get off)	6.4	12.6	14.2	+	+	±	0.7	0.8		0.9		
(e) Planning onward or return journey	7.3	5.8	5.8	-		-	0.4	0.6	+	0.6	±	
(e) Other	11.7	8.1	0.0	-	-	-	6.6	0.0	-	0.0	-	-
Sample size	25,596	27,556	27,812				22,740	17,272		19,091		

Note: N/A – not available as a response category in the survey. (a)–(e) notations in the ‘Activities’ column correspond to the classifications defined for this study. Notations of ‘+’ and ‘-’ are presented when percentages in more recent years are larger and smaller, respectively, than those in older years at  $p < 0.05$ . Notations ‘+’ and ‘-’ are used for comparing two consecutive time points, while notations ‘±’ and ‘=’ are used for two consecutive time points that skipped one time point. Test results for 2004 and 2010 (i), 2010 and 2014 (ii), and 2004 and 2014 (iii)

‘(b) sleeping’ when thinking about their business with their eyes closed, ‘(c) reading’ when reading business-related documents, ‘(d) music’ when studying languages using portable music devices, and ‘(e) other’ when thinking about maths problems with their eyes open. The authors decided to assign ‘working/studying (reading/writing/thinking)’ to ‘(e) other’ as there is no good reason to assign it to any of (a)–(d). If ‘working/studying (reading/writing/thinking)’ were exactly allocated to (a)–(e), then the proportions of (a)–(d) and (e) would be greater and smaller, respectively.<sup>4</sup> The results in Table 5 include ‘any time’ and ‘most time’, but only the latter is utilised here. The sum of the percentages in ‘most time’ is unity, which is also true for direct observations. Each activity with the (a) notation increases over time, and the sum of the activities with the (a) notation comprises 1.9%, 8.1%, and 14.4% in 2004, 2010, and 2014, respectively. This is in line with the trend of ‘(a) mobile phones’ in the present meta-analysis. The percentage was slightly higher in the present meta-analysis at around 25% in 2010. ‘(b) sleeping/snoozing’ trends lower: 3.7%, 3.5%, and 2.8% in 2004, 2010, and 2014, respectively. The percentages in the present meta-analysis were higher. The activity ‘(c) reading for leisure’ also trended lower: 37.9%, 37.0%, and 32.6% in 2004, 2010, and 2014, respectively. In the present meta-analysis, between 2004 and 2014, the percentage points in reduction were similar in ‘(c) reading’, but the percentages themselves were smaller. The activity ‘(d) listening to music/radio/podcast’ trended higher overall between 2004 and 2014, with 3.7%, 8.6%, and 6.8% in 2004, 2010, and 2014, respectively. The sum of the activities with the (e) notation trended lower between 2004 and 2014, with 52.8%, 42.7%, and 43.3% in 2004, 2010, and 2014, respectively. Regarding activities (d) and (e), not only the trend of increasing/decreasing but also the percentages are similar between Lyons et al. (2016) and the present meta-analysis. The present meta-analysis had higher percentages in ‘(a) mobile phones’ and ‘(b) sleeping’ but lower percentages in ‘(c) reading’. This is partly due to the identification of activities made by surveyors’ eyes. Some people use mobile devices for reading, which are registered as ‘(a) mobile phones’ in direct observations but ‘(c) reading’ in questionnaires. Some people close their eyes, which is registered as ‘(b) sleeping’ under direct observation but can be registered as other activities in questionnaires. Percentages of ‘(c) reading for leisure’ were similar between ‘any time’ and ‘most time’, which suggests that people who read tend to spend most of their time reading.

The discussion of similarities and differences here does not lead to clear conclusions, as it is possible that onboard activities differ between Japan and Great Britain in the first place. However, the historical changes in the onboard activities of rail passengers collected by direct observation in Japan and by questionnaires asking the most time spent in Great Britain were similar, and reasonable interpretations were possible in terms of differences in trend and percentages.

The second study uses the Japanese Surveys on Time Use and Leisure Activities in 2001, 2006, 2011, and 2016. The use of data from Japan is the same as in the present meta-analysis, while the survey method of questionnaires and the analysis of trips irrelevant to transportation modes differ from the present meta-analysis. The dataset was the same as that used in Sanko (2023). Although Sanko (2023) analysed travel-based multitasking for

<sup>4</sup> Working and studying were included in the ‘(e) other’ category in Shuppan Forum (2004, 2007) in Supplementary Table 2. They refer to work-related reading (e.g., A4-sized printed material) and study-related reading (e.g., textbooks and reference books) that are not classified as books, newspapers, or magazines. Therefore, they are not comparable with ‘(e) working/studying (reading/writing/thinking)’ in Lyons et al. (2016).

separate trip purposes, the present analysis re-analysed it for all trip purposes combined. As explained in the “[Longitudinal studies](#)” Section, the Time Use Surveys asked respondents to report their primary and secondary activities for each 15-minute time slot. The authors identified the time slots in which the primary activity was travel for any purpose, and calculated the percentage of secondary activities in the identified time slots. The results are presented in Table 6. Again, there was no one-to-one correspondence in the classifications between the Time Use Surveys and the present meta-analysis. However, if it were possible to classify the activities in Table 6 in the way described in front of the names of the activities, then the following considerations would be made. ‘(e) No secondary’ had an extremely large percentage, and only ‘(a or d) TV and radio’, ‘(a or d) Video, DVDs, and CDs’, and ‘(e) Other activities’ exceeded 1%. The sums of ‘(a) Telephone conversation’, ‘(a) Communication by computing and correspondence’, ‘(a or d) TV and radio’, and ‘(a or d) Video, DVDs, and CDs’ were 3.47%, 2.34%, 2.92%, and 3.30% in 2001, 2006, 2011, and 2016, respectively, showing a surprisingly stable trend. Table 6 reveals significant changes between 2011 and 2016. ‘No secondary’ activities accounted for 89.71% in 2016, a decrease of 5.34% points since 2011, while ‘(e) other activities’ accounted for 5.05% in 2016, an increase of 4.68% points since 2011. The classification of ‘(e) Other activities’ should be treated with care. ‘Computing (use of PC)’ and ‘Computer and video games’ are separate categories in 2011 and 2016, but no such categories were present in 2001 and 2006. For the sake of comparability over time, ‘Computing (use of PC)’ and ‘Computer and video games’ were merged into ‘(e) Other activities’ in Table 6. However, most of ‘(e) Other activities’ (0.37% in 2011

**Table 6** Activities by passengers while travelling (% of respondents for all modes of transport)

Activities	2001	2006	i	2011	ii	iii	2016	iv	v	vi
(a) Telephone conversation	0.03	0.02		0.01	=		0.02			=
(a) Communication by computing and correspondence	0.11	0.08	–	0.09			0.19	+	±	±
(b) Sleep and nap	0.25	0.07	–	0.17	+	=	0.21		±	=
(c) Books	0.52	0.26	–	0.37	+	=	0.33		±	=
(c) Newspapers and magazines	0.21	0.13	–	0.15		=	0.16			=
(a or d) TV and radio	2.25	1.54	–	1.60		=	1.37	–	=	=
(a or d) Video, DVDs, and CDs	1.08	0.71	–	1.22	+	±	1.73	+	±	±
(e) Main job	0.10	0.01	–	0.02	+	=	0.07	+	±	=
(e) Shopping	0.00	0.09	+	0.01	–	±	0.16	+	±	±
(e) Homework	0.03	0.04		0.04			0.02		=	
(e) Learning	0.04	0.03		0.03			0.05	+		
(e) Meals	0.23	0.18	–	0.19			0.25	+	±	
(e) Meeting with another person	0.00	0.00		0.51	+	±	0.44	–	±	±
(e) Communication with family	0.01	0.10	+	0.16	+	±	0.18		±	±
(e) Arts	0.01	0.00		0.02	+		0.07	+	±	±
(e) Other activities	0.13	0.18	+	0.37	+	±	5.05	+	±	±
(e) No secondary	95.00	96.57	+	95.06	–		89.71	–	=	=
<i>n</i>	94,270	89,253		98,409			96,207			

Note: (a)–(e) notations in the ‘Activities’ column correspond to the classifications defined for this study. Notations of ‘+’ and ‘–’ are presented when percentages in more recent years are larger and smaller, respectively, than those in older years at  $p < 0.05$ . ‘+’ and ‘–’ for comparing 5-year intervals and ‘±’ and ‘=’ for 10-year intervals, and ‘±’ and ‘=’ for 15-year intervals. Test results for 2001 and 2006 (i), 2006 and 2011 (ii), 2001 and 2011 (iii), 2011 and 2016 (iv), 2006 and 2016 (v), and 2001 and 2016 (vi)

and 5.05% in 2016) belong to ‘Computing (use of PC)’ (0.18% in 2011 and 4.47% in 2016) and ‘Computer and video games’ (0.07% in 2011 and 0.39% in 2016), which should have been classified under (a). This explains the increasing trend of ‘(a) mobile phones’ in this study. Activities with (c) notation related to reading showed an overall decreasing trend from 0.73% in 2001 to 0.49% in 2016. The present meta-analysis found an increasing trend for activities with notations (a) and (d) and a decreasing trend for activities with notation (c). However, the percentages in the Time Use Survey were extremely small.<sup>5</sup> There are some interpretations: (1) a smaller percentage of travellers other than rail has secondary activities<sup>6</sup>, and (2) activities carried out only a part of a 15-minute time slot may not be reported. This means that the percentages calculated from Time Use Surveys are very different from those calculated from direct observations. Note that the percentages in Table 6 were calculated on a time slot basis, which is very similar to the idea of ‘any time’ by Lyons et al. (2016). Time slots consecutively used for travelling can be grouped into a single trip, and the activity that is registered most frequently in the grouped trips can represent the activity of the journey. This is more similar to the idea of ‘most time’ in Lyons et al. (2016).

Before concluding the paper, the strengths and limitations of the present analysis are noted. Six important strengths are: (1) this paper was the first to describe a meta-analysis of travel-based multitasking; (2) the use of observational data from multiple sources, including non-academic literature, covered a long period; (3) the content analysis utilising YouTube videos as a data source is novel; (4) historical changes in the proportion of passenger engagement in each activity were clearly demonstrated by moderator analysis; (5) conclusions did not change for studies without YouTube data, which supports (or at least does not deny) the use of YouTube data for this purpose; and (6) results obtained by direct observations were compared with those from questionnaires. Three limitations are noted: (1) the data from YouTube videos is not comprehensive and is small in size, and its collection was

<sup>5</sup> The proportions engaged in secondary activities while travelling can be considerably lower in time use surveys than in direct observations. Keseru et al. (2015) used time use data from surveys conducted in Flanders, Belgium in 2013 and 2014 and found that 25.4% of those whose primary activity was travel-related reported secondary activities. This is larger than the proportion reported in Table 6 ( $100 - 89.71 = 10.29\%$  in 2016), but smaller than the 95% confidence interval in Fig. 2 panel (e) for direct observations. Note that the Flanders survey is a web-based survey, whereas the Japanese survey in 2016 was both paper-based and web-based. Keseru et al. (2015) noted some misunderstandings about respondents’ secondary activities (e.g., whether the activity occurred during the trip or at the destination (purpose of the trip)), but no concerns were reported in the Japanese time use survey.

<sup>6</sup> Building a bridge between the results in Table 6 and the meta-analysis in this study requires modal shares on a 15-minute time slot basis. One dataset that can be used for this purpose is household travel survey data. Household travel surveys in Japan ask respondents about the travel time and mode for each unlinked trip. Of course, there is still the question of how people report their travel in time use surveys and household travel surveys. Access to the raw data of household travel surveys is not easy, so rough estimates were based on simplifications. Line-haul modal shares of linked trips and their average travel times were published in the Nationwide Household Travel Surveys in Japan in 2015 (MLIT 2024a, 2024b). The percentage of time spent in each line-haul mode is calculated by weighting the modal shares of linked trips by their average travel times. The percentage of time spent on rail (linked trip basis) was 36.9% (note 31.1% for car (driver)). Linked trips contain some unlinked trips, and if 50% of the travel time of the linked trip by rail is spent on the train and the rest on other modes (access to and egress from stations) and waiting (MLIT 2024c). The percentage of time spent on the train for the unlinked trip was 18.5%. If all ‘Computing (use of PC)’ and ‘Computer and video games’ are assumed to be done on trains (where they can be done most easily), the increase of 4.68% points in all modes combined becomes  $4.68/0.185 = 25.3\%$  points increase in rail. If these activities had been carried out in other modes, the expected increase of 25.3% points would be lower. However, a 25.3% point increase in rail is comparable to that in Fig. 2 (a).

entirely manual<sup>7</sup>; (2) most of the studies in the available literature were conducted in Tokyo; and (3) factors other than time trends are not discussed in depth.

In conclusion, this meta-analysis of travel-based multitasking of rail passengers utilised data from direct observations as well as retrospective data from YouTube. Historical changes were statistically examined, and the results showed that activities ‘(a) mobile phones’ and ‘(d) music’ have significantly increased in usage in recent years. The activity ‘(c) reading’ trended downward significantly. However, this may be due to changes in how passengers read, from reading printed matter to reading using electronic devices, the use of which can also be evaluated as ‘(a) mobile phones’. However, in any case, it is evident that the use of electronic devices is trending upward strongly, and an environment that is friendly to mobile activities in railway carriages has had a huge impact on passenger satisfaction. Railway operators may invest in facilities to improve the environment, and governments may build a policy to facilitate the investment. As mentioned in the “[Introduction](#)” Section, a decrease in the value of travel time savings from meaningful use of in-vehicle time can impact the project evaluation. Without considering the proportions of travel-based multitasking on trains, any discussion of a project’s evaluation would surely fail. Such a discussion would require knowing 1) the historical trends in the proportions of travel-based multitasking, 2) the value of travel time savings used for project evaluation, and 3) the project evaluations when different values of travel time are utilised. Even if the general trends of the travel-based multitasking are obvious, such as the increase in mobile phone use, the actual figures should be examined, as this study does.

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## Declarations

**Competing interests** The authors declare no competing interests.

<sup>7</sup> Increasing the data size of YouTube videos is a topic for future study. Two issues are noted: (1) Can the same count results be obtained from direct observation and video content analysis?; (2) Is the population the same for both direct observation and video?

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## References

- Aikyou, Y.: Sukoshi kawatta josei no dokusho keikou: Shachuu no dokusho, 4 nen mae tono hikaku (Women's reading habits that have slightly been changed: Reading on trains compared to four years ago). *Gengo Seikatsu*. **386**, 90–93 (1984). (in Japanese)
- Barker, T.H., Migliavaca, C.B., Stein, C., Colpani, V., Falavigna, M., Aromataris, E., Munn, Z.: Conducting proportional meta-analysis in different types of systematic reviews: A guide for synthesisers of evidence. *BMC Med. Res. Methodol.* **21**, 189 (2021)
- Borenstein, M., Hedges, L.V., Higgins, J.P.T., Rothstein, H.R.: *Introduction to Meta-Analysis*. John Wiley & Sons, Ltd: Oxford (UK) (2021)
- Clayton, W., Jain, J., Parkhurst, G.: An ideal journey: Making bus travel desirable. *Mobilities*. **12**, 1–20 (2017)
- e-Stat: (2023). <https://www.e-stat.go.jp/dbview?sid=0003198751>. (accessed on 2 October 2023)
- East Japan Railway Company: Uniform guidelines on the etiquette of mobile phone use in vehicles. (2003). (in Japanese) [https://www.jreast.co.jp/press/2003\\_1/20030812.pdf](https://www.jreast.co.jp/press/2003_1/20030812.pdf) (accessed on 12 October 2023)
- East Japan Railway Company: (2015). <https://www.jreast.co.jp/press/2015/20150916.pdf> (accessed on 13 October 2023)
- East Japan Railway Company: History of JR East since its establishment. (2023). (in Japanese) <https://www.jreast.co.jp/company/outline/history.html> (accessed on 12 October 2023)
- Gruber, C., Raminger, K., Shibayama, T., Winder, M.: On the Vienna Corso: Changing street use and street design around the Vienna State Opera House 1860–1949. *J. Transp. History*. **39**(3), 292–315 (2018)
- Harada, T., Kawabata, M., Shin, K., Wakigawa, A., Sugimoto, K., Maruyama, A., Nishiguchi, M., Yoshii, K., Sekioka, S., Yoshimura, A., Kai, C., Hozumi, H., Tanaka, Y., Sato, S.: Kansai no densha nai ni okeru medeia riyou chousa (Survey of on-train media usage in Kansai region). *Doushisha Toshokan Jouhou-gaku* (Doshisha J. Libr. Inform. Science). **24**, 64–79 (2014). (in Japanese)
- Kataoka, J., Iwatake, J., Takahashi, M., Hayami, A., Shibata, S., Hara, N.: Working behavior of passengers sitting on trains or subways in the Tokyo metropolitan area. *Japanese J. Physiological Anthropol.* **7**(4), 51–58 (2002). (in Japanese)
- Keseru, I., Macharis, C.: Travel-based multitasking: Review of the empirical evidence. *Transp. Reviews*. **38**(2), 162–183 (2018)
- Keseru, I., Bulckaen, J., Macharis, C., Minnen, J., Glorieux, I., van Tienoven, T.P.: Is travel time wasted? Evidence from a time use survey in Flanders, Belgium. *Proceedings of the 14th International Conference on Travel Behaviour Research*, Winsor, U.K. (2015)
- Kitamura, R.: A preliminary study on variability. *Infrastructure Plann. Rev.* **20**, 1–15 (2003). (in Japanese)
- Lyons, G., Jain, J., Susilo, Y., Atkins, S.: Comparing rail passengers' travel time use in Great Britain between 2004 and 2010. *Mobilities*. **8**(4), 560–579 (2013)
- Lyons, G., Jain, J., Weir, I.: Changing times—A decade of empirical insight into the experience of rail passengers in Great Britain. *J. Transp. Geogr.* **57**, 94–104 (2016)
- MIAT (Ministry of Internal Affairs and Communications): Reiuwa 4 nendo jouhou tsuushin medeia no riyou jikan to jouhou koudou ni kansuru chousa houkokusho (Report of the 2022 Survey on Information and Communication Media Usage Time and Information Behaviour). (2023). (in Japanese) [https://www.soumu.go.jp/main\\_content/000887589.pdf](https://www.soumu.go.jp/main_content/000887589.pdf) (Accessed on 20 October 2023)
- MLIT: (2024a). <https://www.mlit.go.jp/common/001223991.xlsx> (accessed on 12 April 2024)
- MLIT: (2024b). <https://www.mlit.go.jp/common/001224006.xlsx> (accessed on 12 April 2024)
- MLIT: (2024c). [https://www.kkr.mlit.go.jp/plan/pt/research\\_pt/h12/p3-1-4.html](https://www.kkr.mlit.go.jp/plan/pt/research_pt/h12/p3-1-4.html) (accessed on 12 April 2024)
- Mostafa, M.M., Feizollah, A., Anuar, N.B.: Fifteen years of YouTube scholarly research: Knowledge structure, collaborative networks, and trending topics. *Multimedia Tools Appl.* **82**, 12423–12443 (2023)



- Nagamine, S.: "*Dokusho kokumin*" no tanjo: Meiji 30-nendai no katsuji medeia to dokusho bunka (The emergence of the "reading nation": Print media and reading culture in 1897–1906). Japan Editors School: Tokyo. (2004). (in Japanese)
- Ohmori, N., Harata, N.: How different are activities while commuting by train? A case in Tokyo. *Tijdschrift voor Economische en Sociale Geografie*. **99**, 547–561 (2008)
- Osada, S., Yokota, M., Harada, T., Itoga, M.: Densha nai ni okeru jouhou medeia riyou: 10 nenkan no suii (Use of information media on trains: Ten-year transition). *Proceedings of Mita Society for Library and Information Science*, 41–44. (2014). (in Japanese)
- Page, M.J., McKenzie, J.E., Bossuyt, P.M., Boutron, I., Hoffmann, T.C., Mulrow, C.D., et al.: The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *PLoS Med.* **18**(3), e1003583. (2021)
- Pawlak, J.: Travel-based multitasking: Review of the role of digital activities and connectivity. *Transp. Reviews*. **40**(4), 429–456 (2020)
- R Core Team: R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria. (2023). <https://www.R-project.org>
- Russell, M.L.: Travel time use on public transport: What passengers do and how it affects their wellbeing (Thesis, Doctor of Philosophy). University of Otago. (2012)
- Sanko, N.: Travel demand forecasts improved by using cross-sectional data from multiple time points. *Transportation*. **41**(4), 673–695 (2014)
- Sanko, N.: Factors affecting temporal changes in mode choice model parameters. *Transp. Plann. Technol.* **39**(7), 641–652 (2016)
- Sanko, N.: Travel demand forecasts improved by using cross-sectional data from multiple time points: Enhancing their quality by linkage to gross domestic product. *Transportation*. **45**(3), 905–918 (2018)
- Sanko, N.: Updating function model: Model updating method transferable in a wider range of data sizes. *Asian Transp. Stud.* **8**, 100071 (2022)
- Sanko, N.: Travel-based multitasking in Japan between 2001 and 2016: Descriptive analysis. In: Mizutani, F., Urakami, T., Nakamura, E. (eds.) *Current Issues in Public Utilities and Public Policy: Empirical Studies Focusing on Japan*. Kobe University Monograph Series in Social Science Research, pp. 131–148. Springer, Singapore (2023)
- Seeley, J.S., Wickens, C.M., Vingilis-Jaremko, L., Fleiter, J., Yildirim-Yenier, Z., Grushka, D.H., Vingilis, E.: Street racing, stunt driving and ghost riding YouTube videos: A descriptive content analysis. *Transp. Res. Part. F: Traffic Psychol. Behav.* **63**, 283–294 (2019)
- Shuppan Forum: Tsuukin densha no dokusho jijou (The state of reading on commuter trains). *Shuppan Forum*. **2**(11), 6–21 (1986). (in Japanese)
- Shuppan Forum: Tsuukin densha no dokusho jijou '88 (The state of reading on commuter trains '88). *Shuppan Forum*. **4**(11), 6–21 (1988). (in Japanese)
- Shuppan Forum: Tsuukin densha no dokusho jijou '97 (The state of reading on commuter trains '97). *Shuppan Forum*. **13**(11), 1–14 (1997). (in Japanese)
- Shuppan Forum: Tsuukin densha no dokusho jijou 2004 (The state of reading on commuter trains 2004). *Shuppan Forum*. **20**(12), 1–15 (2004). (in Japanese)
- Shuppan Forum: Tsuukin densha no dokusho jijou 2007 (The state of reading on commuter trains 2007). *Shuppan Forum*. **23**(12), 1–14 (2007). (in Japanese)
- Wang, N.: How to conduct a meta-analysis of proportions in R: A comprehensive tutorial. [https://www.researchgate.net/publication/325486099\\_How\\_to\\_Conduct\\_a\\_Meta-Analysis\\_of\\_Proportions\\_in\\_R\\_A\\_Comprehensive\\_Tutorial](https://www.researchgate.net/publication/325486099_How_to_Conduct_a_Meta-Analysis_of_Proportions_in_R_A_Comprehensive_Tutorial) (2018). (accessed on 19 January 2023)
- Wardman, M., Lyons, G.: The digital revolution and worthwhile use of travel time: Implications for appraisal and forecasting. *Transportation*. **43**, 507–530 (2016)
- Wardman, M., Chintakayala, P., Heywood, C.: The valuation and demand impacts of the worthwhile use of travel time with specific reference to the digital revolution and endogeneity. *Transportation*. **47**, 1515–1540 (2020)
- World Bank: (2024). <https://api.worldbank.org/v2/en/country/JPN?downloadformat=excel> (accessed on 12 April 2024)
- Yada, N.: The ratio of readers in a train. *Res. Rep. Kanagawa Inst. Technol. Part. A: Humanit. Social Sci.* **17**, 119–137 (1993). (in Japanese)



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