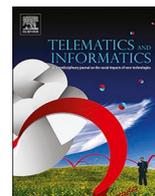


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Examining familial role in mobile news consumption as a sequential process

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ABSTRACT

News consumption is deeply and widely situated in families. Employing role theory as theoretical framework, this study argues that users' familial role would influence their mobile news consumption behavior through shaping their personal news interests and regulating their time budget of news viewing. We extracted data from the server log of the Sohu News mobile application, one of the most popular mobile news applications in China. We found that users with different familial roles demonstrate various sequential patterns of news consumption, as represented by various sequence length and turbulence. This study expands the theoretical horizons by integrating the traditional role theory and big user data analytics to address the mobile news consumption in China.

News consumption is integrated into one's daily habits, which is deeply and widely situated in families (Chaffee and Choe, 1981). The role of family communication processes as antecedents to news media consumption has been well documented (Chaffee et al., 1971, 1973; McDevitt and Chaffee, 2000). Family communication influences individuals' long-term news consumption patterns. News habits is largely acquired in the household context (Vettehen et al., 2012).

Given the rich tradition of studies on news consumption and family communication, limited attention in the literature is paid to how the familial role may impact news consumption behavior in household on individual basis. Individuals' news consumption behavior may situate in their familial role expectation and constrained by their time budget to performance their role commitment (Amatea et al., 1986).

The minimal attention afforded in the literature to the consideration of news consumption behavior is also remarkable. Previous studies have vaguely conceptualized and operationalized the behavior of news consumption as individuals' news topical selection (Pleck, 1977), which cannot holistically reflect the pattern of news consumption behavior. One reason for such lack of attention is that audience surveys based on conventional media platform cannot accurately track news-viewing behavior.

This study consider news consumption behavior as a process that unfolds over time as a sequence of news topics (Poole, 2007). First, the consumption order of news topics indicates personal preferences and the attention level to types of news. Users typically glance first at the main stories of a news outlet (e.g., newspaper or online news sites) and then concentrate on those that they found to be particularly interesting¹. The concentration time for news topics that are consumed first is usually longer than that in subsequent visits (Boczkowski, 2010). Moreover, the description of news topic sequences consumed by a user reflects how the user manages his/her media resources and the user's control over news information flow. In the era of mobile communication, the power of control over

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¹ <https://www.wikihow.com/Read-a-Newspaper>

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news information flow may have shifted from news professionals to ordinary users, because users can freely select news stories from a large volume of news repertoire, represented as different news topic sequences among individuals (Picone et al., 2015).

Employing the role theory, this study examines how individuals' mobile news consumption behavior is situated in their familial roles. Following the computational approach of news consumption studies (Nelson and Lei, 2018; Peng and Zhu, 2020), this study employs the tracking data to examine users' digital news consumption. This study conducts a sequence measurement of news consumption behavior to examine the impacts of the familial role on news consumption. In the era of mobile communication, mobile platforms track the fine-grained records of news-viewing sequences that allow researchers to trace news-viewing behavior, and consequently, empirically investigate the differences in news-viewing sequences among individuals.

1. Familial role and users' news consumption behavior

Role theory is concerned with how the roles of individuals characterize their behavioral patterns in social life (Biddle, 1986). News consumption is connected to a user's familial role (Robinson, 1981). The news habits originate in home, which is the most widely and naturally situated context of news consumption (Edgerly et al., 2018).

Individuals' familial roles are assessed in terms of two dimensions: the role reward value dimension, and the role commitment level dimension (Amatea et al., 1986). The former means individuals' role expectation, that is, the level of importance or value attached to perform in a given familial role. Individuals behave in manners that are predictable depending on their expectations of familial role positions, which are the product of a role-making process (Stryker, 1968; Callero, 1985; Biddle, 1986; Mead, 1964). The latter refers to the role commitment, which indicates the spending of personal time and energy resources to perform a given role (Amatea et al., 1986). It is found that news consumption could be heavily shaped by individuals' domestic duties: when, how, and what they consumed had to fit in with demanding household schedules and responsibilities to others (Morley, 1986).

In this regard, this study argues that individuals' familial role will influence their news consumption behavior. In specific, individuals' familial role expectation will determine the priority of news topics, which further shapes the transition of news topic sequence. In addition, the time budget for different familial roles constrains the length and complexity of news-viewing sequences.

According to life role salience scales (Amatea et al., 1986), this study employs two proxy variables of familial role: marital status and parental status. The former refers to whether users are married, whereas the latter indicates whether the users have child/children.

2. Role expectations and news consumption behavior

The familial role is critical for defining individuals' self-image (Banton, 1965). Roles in the form of expectations guide an individual's attention and information retrieval (Martin and Halverson, 1987; Biddle, 1986; Mead, 1964). An individual's behavior reflects his/her tendency toward his/her familial role expectations. These behavioral motivations are related to the role-typed domains that can be observed in news preference (Knobloch Westerwick and Alter, 2007). The members of the audience sustain their familial roles by selectively favoring certain types of information (Knobloch Westerwick and Alter, 2007). Users with different preferences toward news topics exhibit varying levels of motivation and gratification for news viewing, which moderates the cost and benefits of news consumption (Benesch, 2012), thereby resulting in different priorities of topics for news viewing among users.

For example, users with different parental status indicate that they may exhibit varying interests in certain types of news topics. Users who have the burden of childcare may have developed a considerable interest in certain types of news information. Studies have found parents consumed more entertainment news but show less interests in public issues, since the stress caused by burden of childcare was associated with increased comedy and decreased hard news in the viewing diet (Anderson et al., 1996). In addition, users whose children are at school age, would model news consumption in a multi-device media environment, even on personalized mobile devices (Edgerly et al., 2018). As the creators of their children's media environments, parents would consume less news with violent contents (Nathanson, 2015).

3. Time budget and news consumption behavior

To perform their familial roles, individuals will dedicate their time resources to fulfill the role commitment. News consumption is a typical behavior during leisure time (Robinson, 1981), and the limited time budget for users with certain familial roles will affect their news consumption behavior.

Previous studies have found that marital status significantly predicts news reading in days per week (Chan and Leung, 2005). Married respondents spend considerably more time on TV news compared with single respondents (Benesch, 2012). Similarly, the burden of childcare considerably influences users' available time for news consumption. With the increasing stress caused by childcare, the audience reduces its news-viewing activities, which further shortens the news viewing sequences (Anderson et al., 1996). Moreover, when the time budget is limited, users may have less chance to switch between news topics. Empirical studies have found that households with child/children spend less time on TV news and more on radio news (Benesch, 2012).

Studies have also shown that single parents (i.e., those single parents who are divorced or separated), who are lack of support from core family members, will consume more TV news viewings, since they could not afford the time cost of other leisure options outside the home and their childcare responsibilities further reduced their ability to get out (Haddon, 2000).

4. Conditional factors of age and gender on familial role

Family roles are conditioned on gender. Gender indicates and in some social contexts regulates the familial role in the household (Burton, 1996). Females and males generally perform different family tasks, such as the marital division of family labor (Pleck, 1977). Female who have get married and given birth indicates that they act as housewives and mothers. Studies have shown that the family roles across gender shows different media viewing behavior. For female, the transition of parental status may cause the lack of interest in public affairs news, due to the burden of childcare, which may further lead to the transition of news consumption patterns, especially in the social contexts of traditional division of roles across gender (Vettehen et al., 2012).

Age is a proxy variable of cohort which helps to observe the cohort effect of transition of familial role on news consumption behaviors. Family has age norms concerning the transition from childhood, teenager, to parenthood, grandparenthood and even great grandparenthood (Burton, 1996). The difference of news consumption behavior between age groups indicates the effect of transition of familial roles on the news consumption behavior.

In this regard, this study defines the familial role by crosstabbing users' marital status, parental status, age, and gender. Users with different familial roles will exhibit different patterns of news consumption behavior. As reviewed previously, these different patterns of news consumption behavior are represented as differences of priority of news topics and the length and complexity of news viewing, which further shapes and quantifies news topic sequences (Boczkowski, 2010). Therefore, we hypothesize that

H1: The differences in the familial roles of users result in varied topic sequences during news consumption.

5. Temporal patterns of news consumption

An individual's news consumption behavior is not only individual variant but also time variant. We argue that the sequence of news consumption behavior is constrained by the user's daily rhythms. The user's activities are structured into different schedules. The temporal pattern of news consumption shows how news consumption behavior fit into their daily routine (Boczkowski, 2010). First, users exhibit different degrees of availability for various news information at different time sections of a day. News consumption behavior is linked to how much leisure time is available to an individual (Bogart, 1989). Previous studies have found a higher total usage level of mobile news on workdays compared with that on weekends (Vojnovic, 2008; Tang et al., 2012). Empirical studies have also found that most audience members are available in the morning and evening for consuming news (Boczkowski, 2010; Bogart, 1989). Moreover, audience members are more likely to read newspaper on Sunday. In the digital age, users also log on to online news sites during the same part of the day, with the peak time in the morning, before undertaking work chores, and during lunch time (Boczkowski, 2010).

Moreover, news production is highly scheduled and routinized by time sections. From the perspective of news production, time is a crucial factor for delivering news. News organizations deliver certain types of news stories according to their audiences' daily and weekly rhythms because media use time is a precious resource for which news organizations compete (Zhang and Ha, 2015).

To cope with time budget and the availability of news information in news channels at different time sections, users may develop, form, and maintain their news consumption behavior on a selected number of news channels and create their media repertoires (Boczkowski, 2010; Taneja et al., 2012). During the section with a tight time budget, consumers may optimize their allocation of news collection from their news repertoires, as represented by short and homogeneous news topic sequences (Zhang and Ha, 2015). For example, during work hours, users may pass on certain types of news and search for specific news that is available or being promoted at that time. During the time section when they have lower time pressure, users may deliberately select and consume news from their news repertoire as represented by long news topic sequences. In this regard, the sequence of news consumption reflects how users organize their time resources and how they exercise control over their news information flow (LaRose, 2010; Rosenstein and Grant, 1997; Webster and Phalen, 1997). Therefore, people may exhibit different patterns of news consumption during work and leisure times, as indicated by the different news topic sequences of individuals. The section of the day and the day of the week (weekend/weekdays) are the two most widely used time factors that differentiate work and leisure times (Peng et al., 2020; Peng and Zhu, 2020). We hypothesize that

H2: Users show different topic sequences of news consumption at different time sections. In specific,

H2a: Different time sections of the day result in varied topic sequences during news consumption. Individuals demonstrate different patterns of topic sequences during news consumption at various sections of the day.

H2b: The days of the week (i.e., weekdays and weekends) influence the pattern of topic sequences during news consumption. Individuals demonstrate varied patterns of topic sequences during news consumption on weekdays and weekends.

6. Method

6.1. Data collection

Data were extracted from the server log of the Sohu News mobile application, one of the most popular mobile news applications in China. The total revenues for the fourth quarter of 2016 were US\$ 412 million, when the data for this study were collected. In terms of user ratio of mobile applications in 2016, Sohu News mobile application ranked 9th (10%) in China, following Toutiao (14%) (Li et al., 2016). During June to August 2014 in China, Sohu News apps ranked the top two mobile apps in news category by total number of unique visitors and Monthly Active User (MAU), with average weekly UV (User Visit) of 56.47 million².

We randomly selected 0.1 million users according to their user ID. The total number of users included in our dataset was 110,003

Table 1
Transition Rates among Topics (From Left to Top).

	SP	IT	HE	RE	HC	MA	MI	ED	FD	SO	IR	PA	AU	UP	LO	EN	MR
SP	0.54	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.07	0.04	0.02	0.02	0.03	0.01	0.09	0.04
IT	0.03	0.42	0.02	0.01	0.02	0.04	0.03	0.02	0.03	0.07	0.04	0.03	0.04	0.03	0.02	0.09	0.05
HE	0.02	0.02	0.39	0.01	0.02	0.02	0.02	0.02	0.06	0.07	0.03	0.06	0.03	0.03	0.02	0.12	0.08
RE	0.03	0.02	0.02	0.39	0.03	0.05	0.03	0.03	0.03	0.09	0.04	0.03	0.03	0.05	0.03	0.07	0.04
HC	0.02	0.02	0.02	0.01	0.41	0.02	0.04	0.02	0.03	0.07	0.05	0.03	0.03	0.04	0.02	0.10	0.07
MA	0.03	0.03	0.02	0.03	0.02	0.38	0.04	0.03	0.03	0.08	0.07	0.02	0.03	0.04	0.03	0.08	0.04
MI	0.02	0.02	0.01	0.01	0.03	0.03	0.46	0.02	0.02	0.06	0.13	0.02	0.02	0.03	0.01	0.06	0.03
ED	0.03	0.02	0.02	0.02	0.03	0.03	0.04	0.38	0.03	0.11	0.05	0.04	0.02	0.05	0.03	0.08	0.04
FD	0.04	0.02	0.04	0.01	0.02	0.02	0.02	0.02	0.37	0.08	0.04	0.04	0.02	0.04	0.02	0.15	0.06
SO	0.03	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.04	0.43	0.05	0.04	0.03	0.05	0.02	0.10	0.05
IR	0.03	0.02	0.01	0.01	0.03	0.04	0.10	0.02	0.03	0.07	0.45	0.02	0.02	0.03	0.02	0.07	0.03
PA	0.02	0.02	0.04	0.01	0.02	0.02	0.02	0.02	0.04	0.09	0.03	0.34	0.02	0.03	0.02	0.16	0.10
AU	0.02	0.03	0.02	0.02	0.02	0.03	0.03	0.01	0.03	0.08	0.03	0.03	0.49	0.03	0.02	0.08	0.06
UP	0.03	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.04	0.11	0.05	0.03	0.02	0.38	0.03	0.09	0.04
LO	0.03	0.02	0.02	0.03	0.02	0.04	0.03	0.04	0.03	0.10	0.05	0.03	0.03	0.05	0.36	0.07	0.04
EN	0.03	0.02	0.02	0.01	0.02	0.02	0.02	0.01	0.05	0.06	0.03	0.05	0.02	0.02	0.01	0.54	0.08
MR	0.02	0.01	0.03	0.01	0.02	0.02	0.02	0.01	0.03	0.06	0.02	0.05	0.02	0.02	0.01	0.14	0.49

Notes: SP = Sports; IT = Information Technology; HE = Health; RE = Real Estate; HC = History and Culture; MA = Management; MI = Military; ED = Education; FD = Food; SO = Social News; IR = International Relationships; PA = Parenting; AU = Automobile; UP = Urban Planning; LO = Loan; EN = Entertainment; MR = Marital Status

with 28.4 million news-viewing records. To track the news-viewing behavior of these users, we filtered them and selected a panel sample based on the following criterion: the minimum number of active days should not be less than 20 from July 13, 2016 to December 30, 2016.

Finally, 37,942 users, with a total of 2,415,753 viewing records in the data, were retained for analysis. The variables incorporated into the dataset included the information of users (e.g., gender, age, parental status, registration time, and marital status) and their news-viewing history (i.e., time of news viewing, titles and full text of news).

6.2. Identification of news topics

For each news collection, the present study adopted an automatic content analysis method to identify the topics. The method called latent Dirichlet allocation (LDA) topic modeling has been widely used in the field of natural language processing in computer science (Blei et al., 2003; DiMaggio et al., 2013). The algorithm of LDA topic modeling is an unsupervised text mining method that extracts hidden thematic structures based on words and their co-occurrences in a collection of documents (DiMaggio et al., 2013). This approach generates groups of terms (i.e., words used in documents) that are associated by themes, and the strength of the documents exhibiting such themes are assessed (DiMaggio et al., 2013).

This study limited the number of topics from 5 to 30; that is, the program was requested to generate 5 to 30 topic clusters. We test the LDA reliability employing the following steps. We firstly eye browsed the classification results. It is found that the classification results with 15 to 20 topic clusters are with higher face validity. We then compared the results with the pre-defined news categories on the platforms, and named the news topic clusters based on the pre-defined news categories (e.g., domestic news, entertainment, sports, etc.). Third, according to previous studies which suggested reliability evaluation (DiMaggio et al., 2013), we randomly selected 1000 news entries and coded the results by two independent coders. We compared the coding result with the result of LDA topic modeling. It is found that the number of topics assigned to 17 has the highest intercoder agreement (Scott's Pi = 0.81).

As shown in Table 1, the 17 topics are sports, information technology (IT), healthcare, real estate, history and culture, management, military, education, food, social news, international relations, parenting, automobile, urban planning, loan, entertainment, and marriage relations. The 20 most discriminant words for each topic are listed in Appendix A.

6.3. Construction of news consumption sequences

We constructed news consumption sequences as follows. For each user, we constructed two news-viewing sequences per day, namely, work hours (i.e., 8:00 to 18:00) and non-work hours (i.e., 0:00 to 8:00 and 18:00 to 24:00). Then, we defined the topics of news stories that users view as sequence states, and 17 states were included. For example, user A viewed three news stories about politics, entertainment, and sports at one time section; therefore, the sequence of news viewing for user A will be "Politics-Entertainment-Sports." We calculated the state transition rate among news topics by using an R package of "TraMineR".

² <https://www.chinainternetwatch.com/8404/tencent-news-app/>, retrieved 07/10/2020.

Table 2
Results of Mixed MDMR.

Independent Variables	Statistic	Significance
Omnibus	0.0168	0.0164
H1: Familial Roles		
G2 (Middle, Female, Single, No Children)	0.00026	0.002
G3 (Older, Female, Single, No Children)	0.000576	0.000
G4 (Young, Male, Single, No Children)	0.000292	0.001
G5 (Middle, Male, Single, No Children)	0.000501	0.000
G6 (Older, Male, Single, No Children)	0.000493	0.000
G7 (Young, Female, Married, No Children)	0.00065	0.000
G8 (Middle, Female, Married, No Children)	0.000294	0.001
G9 (Older, Female, Married, No Children)	0.000302	0.001
G10 (Young, Male, Married, No Children)	0.000367	0.000
G11 (Middle, Male, Married, No Children)	0.000418	0.000
G12 (Older, Male, Married, No Children)	0.000364	0.000
G14 (Middle, Female, Single, With Children)	0.000368	0.000
G19 (Young, Female, Married, With Children)	0.000524	0.000
G20 (Middle, Female, Married, With Children)	0.000254	0.003
G21 (Older, Female, Married, With Children)	0.000177	0.036
G22 (Young, Male, Married, With Children)	0.000557	0.000
G23 (Middle, Male, Married, With Children)	0.000806	0.000
G24 (Older, Male, Married, With Children)	0.000754	0.000
H2: Time Factors		
Time Section	0.000504	0.000
Weekday	0.000167	0.051
Control Variable		
Experience	0.001076	0.000

Note: ***p < 0.001. **p < 0.01. *p < 0.05.

Reference Group is G1 (Young, Female, Single, No Children)

6.4. Modeling news consumption sequences

We performed multivariate distance matrix regression (MDMR) analysis to evaluate associations among individual differences in news-viewing sequence and quantitative traits, such as familial roles and the temporal patterns of news consumption. The day was divided into work hours (i.e., 8:00 to 18:00) and non-work hours (i.e., 0:00 to 8:00 and 18:00 to 24:00), and the days of the week were classified as weekdays (i.e., Monday to Friday) and weekends (i.e., Saturday and Sunday). Experience on the platform is used as the control variable, which is measured as the duration from the time the user registered on the platform to the time of the news-clicking behaviors.

We measured the variable “familial role” by constructing a crosstab of the variables marital status, parental status, gender, and age. Marital status is classified into whether the users are married or not, which is a self-reported variable that the users provide when they register in the system. Parental status is a dichotomous variable that states whether the user has a child/children. We classified age into three groups (i.e., 23 years or younger, 24–40 years, and 41 years or older). Therefore, the variables of familial role were divided into 24 groups (i.e., 2 marital status groups × 2 parental status groups × 2 gender groups × 3 age groups, see Table 2 for the detailed definition of the 24 groups).

To conduct sequence analysis using MDMR, we first constructed a news topic sequence for each user at each section of the day (i.e., work hours or non-work hours). For example, a user may read the following five news stories in sequence at a given time section on a certain day: “Sports–Sports–Military–IT–Entertainment”.

Second, we calculated the distance matrix (D) of two news-viewing sequences by using the spell optimal matching (Spell OM) method. The distance matrix was represented as a symmetric $n \times n$ distance matrix. The elements in the i^{th} row and j^{th} column ($i, j = 1, \dots, n$) of D, D_{ij} , denote the distance between the two news-viewing sequences. The distance between two sequences was defined as the result of a function $d(Y_i', Y_j')$ that quantifies the dissimilarity of the two news-viewing sequences. Spell OM measures the dissimilarity between two sequences, x and y , as the minimum total cost of transforming one sequence, e.g., x , into another sequence, y , through either the insertion or deletion of tokens or substitution among tokens (Studer et al., 2011). In this study, we randomly selected 510 users with 14,056 sequences to perform the follow-up analysis due to the high computational cost of building the distance matrix.

Third, we conducted MDMR to evaluate associations among the individual differences of news-viewing sequences by using the distance matrix as the dependent variable. MDMR tests the sum of squared distance between the sequence data and a set of covariates (McArtor, 2017a, 2017b), including the users’ familial roles, time factors (i.e., section of the day and day of the week), and users’ experiences of adopting the platform. In contrast to the conventional regression model, MDMR considers the differences among the news-viewing sequences of users as the dependent variable, which is represented as the multivariate distance matrix.

All analyses were conducted in R using the MDMR package (McArtor, 2017a, 2017b), which is available for free on the Comprehensive R Archive Network. The computation of p-values is currently contingent upon permutation tests, which can be

computationally infeasible. We further cross-validate the results by comparing the regression results of MDMR and the results of the regression model in terms of the sequential, frequency, and diversity measurements, as shown in [Appendix B](#).

7. Results

7.1. State transition between news topics

The transition rate between each couple of states (s_i, s_j) (i.e., news topics) refers to the probability of switching at a given position from news topics s_i to news topics s_j . It is calculated as

$$p(S_j|S_i) = \frac{\sum_{t=1}^{L-1} n_{t,t+1}(S_i, S_j)}{\sum_{t=1}^{L-1} n_t(S_i)}$$

where $n_t(s_i)$ is the number of sequences that do not end in t with state s_i at position t , and $n_{t,t+1}(s_i, s_j)$ is the number of sequences with state s_i at position t and state s_j at position $t + 1$ ([Studer et al., 2011](#)).

[Table 1](#) presents the matrix of transition rates for news sequences. Each row provides a transition distribution from the originating state s_i at time t to the states at $t + 1$. That is, each row total is one. The transition rates provide information about the most frequent state changes observed in the data along with, on the diagonal, an assessment of the stability of each state ([Studer et al., 2011](#)).

As indicated in [Table 1](#), the highest transition rate for each row is self-transition, as evidenced by the high transition value in the diagonal, which ranges from 34% to 54%. This result indicates that users have a higher probability of consuming the same news compared with transitioning to a different news topic. In addition, social news and entertainment are topics that have high probabilities to be transitioned to, as evidenced by their transition rate values, which are considerably higher than those of other news topics. Mobile platform users are commonly interested in social news and entertainment. Regardless of the topics that users are interested in, they will most likely transit to these two topics. The result indicates that the mobile news consumption shows a tendency of sensationalism and tabloidization with anecdotal, lifestyle or curiosity content ([Palau-Sampio, 2016](#)). Users consume news not only for instrumental purpose, but for hedonic reasons ([Frissen, 2000](#)). The results echoes previous studies by [Karlsson \(2016\)](#) and [Chakraborty et al. \(2017\)](#).

A clustering pattern of users' news interests has also emerged. Users who express interest in international relations have a high probability of transitioning into military news (transition rate = 10%), and vice versa (transition rate = 13%). Similarly, the transition rate from news topics of "parenting" to that of "marital relationships" is 10%, thereby inferring that users who view parenting news are likely to transition to news about marital relationships.

7.2. MDMR models

We present the results of the MDMR model in this section. [Table 2](#) presents the results of the mixed MDMR model. We selected Group 1 (i.e., young single female without children) as the comparison group because the number of cases in Group 1 is relatively large. Most groups comprising different familial roles exert a considerable effect on predicting the variation in the topic sequences of news consumption. Therefore, H1 is supported. The difference in familial role will lead to variations in news consumption sequences.

To demonstrate the influence of the familial roles on the differences of individual news topic sequences, we further compared the sequence turbulence and length among groups conditioned on the independent variables. Sequence turbulence is a metric proposed by [Elzinga and Liefbroer \(2007\)](#) that measures the stability of a sequence. Sequences with many distinct states and state changes are considered more turbulent than those with fewer ones ([Elzinga and Liefbroer, 2007](#)).

[Fig. 1](#) shows the differences in sequence turbulence and length among the groups. The sequence turbulence of single females without children (i.e., Groups 1, 2, and 3) increased with age. This pattern is not observed among females of other familial roles (e.g., married females with children and married females without children). In addition, the sequence length decreased among single females without children but increased among married females with children as age increases.

These results indicate that in comparison with females who are taking the role of housewives and parents, single females have less time for news consumption but exhibit high transition between news topics as age increases. In comparison with female taking the housewife and parental roles, the family roles of single female are more self-oriented, which determines that their news interests are more diversified. By contrast, females with the familial role of housewives and mothers spend an increasingly longer time on news consumption as their age increases. Along with the increase of age, their familial role transits from mothers of preschool child to mothers of adult child. The transition of familial role determines the time availability, which further influences the sequence length of news consumption. The burden of taking care of preschool children is considered more time consuming than that of school-aged children. When the children are still small, females in the household has little time and energy to maintain news consumption ([Frissen, 2000](#)).

As indicated in [Fig. 1](#), parental status has no effect on sequence turbulence and sequence length among males at any age, as evidenced by the sequence turbulence and sequence length showing no differences between married males without children (i.e., Groups 10, 11, and 12, House Husband) and married males with children (i.e., Groups 22, 23, and 24, Father/Grandfather). The change in familial role does not influence news consumption behavior among males. The result indicates that male would not change their news consumption behavior (both news interests and news viewing length) when their familial role transit to parenthood. The transition of parental status has very little influence on males' familial role expectation and their time budget. The result echoes previous study which argues that, in the past 20 year, the time pressure for male is not significantly increase in comparison with

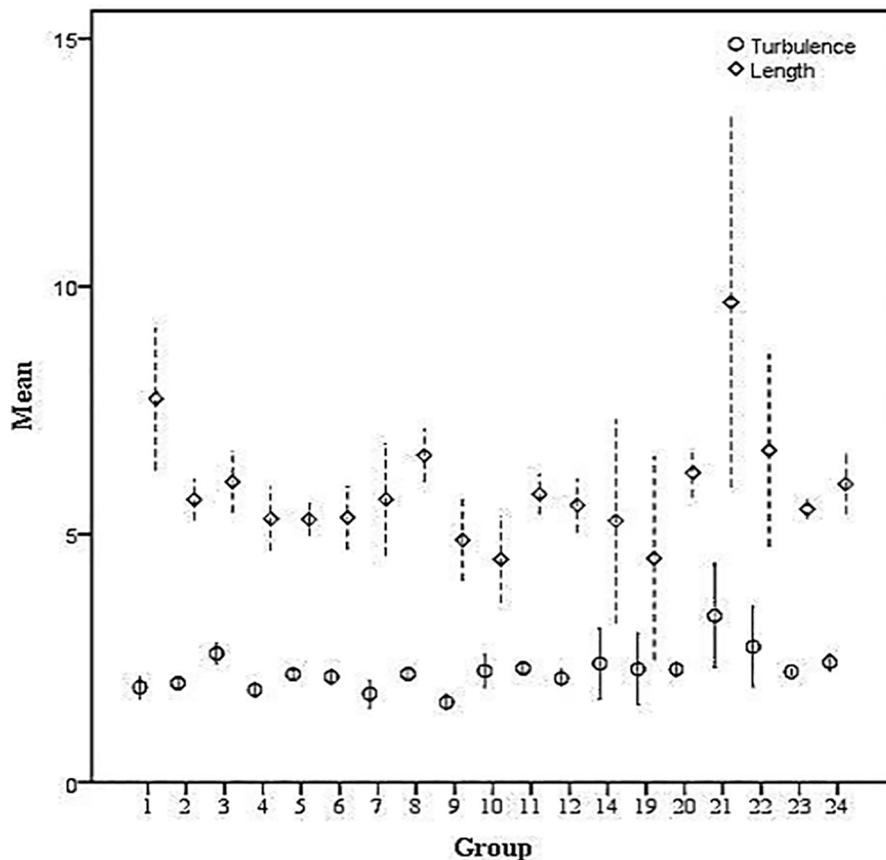


Fig. 1. Comparison of sequence turbulence and sequence length among familial roles. Note: Sequences with many distinct states and state changes are considered more turbulent than those with fewer ones.

female. Among men between 25 and 55, the time spent both paid labor and on child caring tasks has increased a little (Frissen, 2000).

As shown in Table 2, the value of the MDMR test statistic for section of the day is 0.0005 ($p < 0.001$), which indicates that different sections of the day result in differences in topic sequences during news consumption. As shown in Fig. 2, the sequence turbulence of news viewing during spare time is higher than that during work time. Individuals also demonstrate different patterns of topic sequences for news consumption during non-work and work times. However, no significant difference in the topic sequence for news viewing is found between weekdays and weekends. During weekdays and weekends, users show similar patterns of topic sequences of news consumption. The MDMR test statistic for weekday is 0.0002 ($p > 0.05$). Fig. 2B also indicates no difference in sequence turbulence between weekdays and weekends. Therefore, H2 is partially supported.

8. Discussions

This study adopts role theory as a framework to understand how individuals consume news on mobile platforms. The overall sequential rhythms of news consumption are described by constructing a topic transition matrix. Users have a higher probability of consuming the same topics compared with transitioning to a different topic. In addition, social and entertainment news are topics with higher probabilities of being transitioned to.

Furthermore, this study applies MDMR modeling to examine the factors that influence individual differences in news-viewing sequence. It also explores the norm of news consumption among familial roles. Different familial roles demonstrate varied sequential patterns of news consumption, as represented by distinctive sequence lengths and turbulence and transition patterns. Meanwhile, the sequence pattern of news consumption is deeply embedded into the rhythms of daily life. The news preferences of users are recursively activated within their daily social life (Taneja et al., 2012). The MDMR model suggests the duality of mobile news consumption behavior. That is, users actively select news according to their familial roles, and users' news consumption behavior on mobile media platform is bound by the routines of daily life that is structured by social forces.

8.1. News consumption as a family function

Previous research have widely documented that news consumption has become a function of family situation. Family members

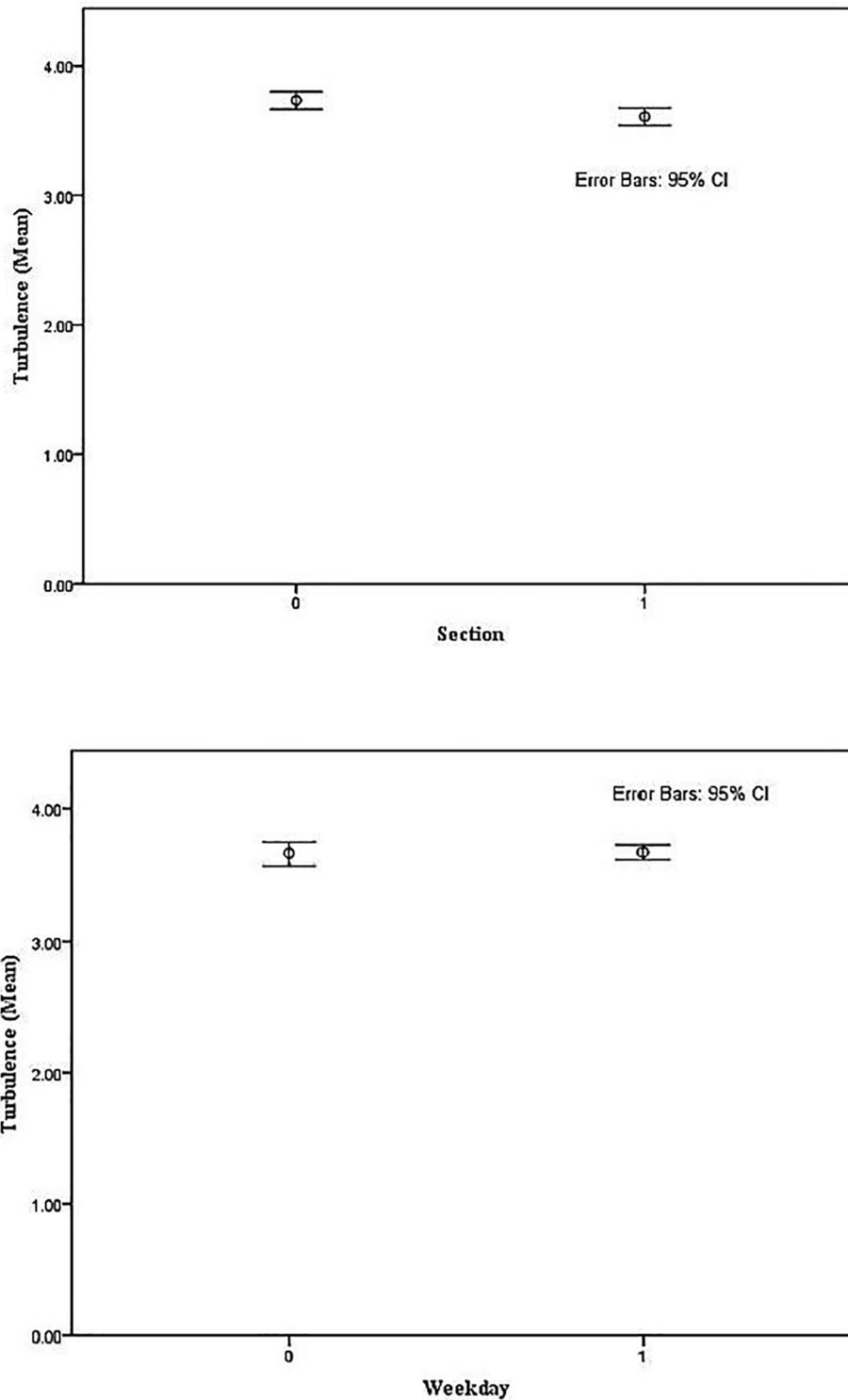


Fig. 2. Comparison of sequence turbulence between time sections and weekdays.

contribute to the common household culture through media consumption at home, which further shapes the news consumption habits of family members(Stone and Wetherington, 1979). This study contributes to this line of research by further investigating how different family roles would shape users' news consumption behavior on mobile news platforms on individual basis. We found that news consumption behavior is deeply rooted into the familial role of users. The familial role identity of a user is shaped by the

combination of marital status and parenthood status, and conditioned on gender (Daly, 1987). Users with different familial roles demonstrate various news interests and different time budget, which influences the news topic priority, transition of news topics, and complexity of news consumption sequences.

Moreover, this study expands the horizon of the role theory in explaining the news consumption behavior in Chinese context. The results demonstrate the unique feature of mobile news consumption in mainland China. This study found that parental status has no effect on sequence turbulence and sequence length of news viewing among males at any age. The result indicates the dominant ideology concerning the appropriate household activities of the two sexes in mainland China. The husbands' family role is generally unresponsive to change and husbands are less likely to increase his family duties as their parental status changes. In China, women are more likely to be segregated into inferior jobs, like household work and child care. The sex segregation of both family work and paid work in China insulates men's family role from the changes in the female family role (Pleck, 1977).

8.2. Sequence perspectives of news consumption behavior

From the measurement aspect, conventional measurement over-reduces behavioral variation in the news consumption process. Previous studies have taken aggregated measures to quantify the intensity of news consumption (e.g., frequency and duration) and diversity of news topics that a user has consumed. The widely adopted intensity- and entropy-based measurements of news consumption summarize behavioral features into a single statistic. In this regard, these longstanding measurements oversimplify the behavior of news reading by neglecting prior news viewing behavior and transition between news topics.

To unravel the complexity of news-viewing behavior, this study conceptualizes news consumption behavior as the process of news topic viewing at a given time; that is, an ordered list of news topics for each user at each time unit. We further calculate the distance matrix of the sequences of news consumption to quantify individual differences in a news-viewing sequence. The sequence perspective of news consumption behavior covers nuance variation and heterogeneity in news consumption, such that sequence measurement provides order and transition variation.

8.3. Methodological contribution

This study contributes to methodological improvements in explaining news consumption behavior by adopting a sequential analysis method. In particular, it adopts MDMR, which has been used in genetic analysis, to quantify the covariates responsible for the individual differences of news-viewing sequences. Compared with conventional methods in social sciences, sequential analysis provides a new approach for empirically describing and quantifying individual sequential variation. We further compare the results of the regression model with that of the sequential, frequency, and diversity measurements. Appendix B presents the results of MDMR and multilevel regression on news-viewing times and news topic diversity. The familial role and time factors are relevant in explaining the sequential differences but fail to clarify frequency and diversity differences among users. These results suggest that conventional regression models with static measures of news consumption behavior over-reduce the heterogeneity of news consumption compared with the sequential approach. The sequence approach provides a holistic view by dealing with entire trajectories of news viewing, which allows researchers to determine trajectory patterns that account for all states (i.e., news topic) of news consumption during the period being considered (Studer and Ritschard, 2016).

8.4. Limitations and further research

This study adopts one of the most popular mobile platforms in China to investigate the news consumption behavior. However, the single data source used in this study cannot be utilized to compare the differences in news consumption patterns across media. Future studies should use cross-platform data to obtain a panoramic picture of how and why familial role influence individual news consumption behavior on various new media platforms.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A

Table A1
Results of News Topic Classification by Topic Modeling.

SP	IT	HE	RE	HC	MA	MI	ED	FD	SO	IR	PA	AU	UP	LO	EN	MR
season	cellphone	hospital	price	history	company	aircraft	university	food	journalist	country	kids	automobile	city	bank	netizen	time
player	user	body	city	culture	market	missile	major	cooking method	crew	problem	baby	vehicle model	traffic	staff	movie	friend
team	product	patient	house price	emperor	enterprise	navy	leader	egg	Mr.	president	mum	engine	center	insurance	microblog	man
champion	Apple	doctor	market	art	economy	military	problem	taste	vehicle	government	student	space	region	regulation	program	woman
sports	tech-nology	food	RMB	work/project	industry	system	secretary	gourmet	policy	world	teacher	power	park	salary	celebrity	husband
time league	brand smart	effect skin	house land	period story	group domain	troops aircraft carrier	society country	corn address	man driver	relations economics	daughter school	brand system	project weather	institution rural area	photo fans	feeling thing
football	XIAOMI	illness	policy	tradition	finance	tech-nology capacity	nation-wide college	pepper	accident	international media	parents	aspect	subway	standard	actor	WeChat
club	function	exercise	housing	people	product	weapon	eng-neering cadre	ingredi-ents	miss	mother and father son	mother	market	scenic	informa-tion	fashion	mar-riage
athlete	system	approach	residence	world	fund	aviation	project school	vegetable	policeman	event	son	sales	engineer	medical care	audience	career
player	platform	human body	real estate market	era	limited company	aviation	project school	beef	traffic	politics	time	car body	tourist	enterprise	time	love
coach	game market	impact time	house property	epoch antique	project data	air force equip-ment	air force equip-ment	time hot pot	situation behavior	region human	mother father	car	railway culture	individual policy	figure director	period zodiac
word	network	symptom	area	time	world	combat aircraft	staff	Doufu	telephone company	society	period	price	plan	organiza-tion	goddess	wife
soccer fans	Internet	nutrition	project	place	platform	mission	people	restaurant	company	earth	daddy	problem	architec-ture	society	TV series	life
oppo-nent	WeChat	vitamin	loan	Mr.	tech-nology	strategy	institution	nutrition	security	time	classmates	customer	time	depart-ment	feeling	peer
back-board score	data	function	owner/proprietor	spirit	energy	US army	central	delicious	criminal suspect case	result	problem	time	hour	residence	media	rela-tions
women-s volleyball	Samsung	diet	property developer	nation-ality	business	army	teacher	flavor	hospital case	policy	family	gearbox	route	income	character	emotion
gold medal	consumer	fat	data	calli-graphy	international	warcraft	examinee	food stuff	hospital	benefits	children	Volkswag-en	environ-ment	system	tempera-ment	better half

Notes: SP = Sports; IT = Information Technology; HE = Health; RE = Real Estate; HC = History and Culture; MA = Management; MI = Military; ED = Education; FD = Food; SO = Social News; IR = International Relationships; PA = Parenting; AU = Automobile; UP = Urban Planning; LO = Loan; EN = Entertainment; MR = Marital Relationships

Appendix B

Table B1

Comparison among Sequence-based, Frequency-based, and Diversity-based Measurement of News Consumption.

	MDMR		Mixed Entropy			Mixed Frequency		
	Statistic	p Value	Coff.	Std.	p Value	Coff.	Std.	p Value
section	0.000504	0.000	-0.0021	0.0042	0.615	0.1029	0.1262	0.415
weekday	0.000167	0.051	-0.0002	0.0044	0.969	0.1594	0.1294	0.218
experience	0.001076	0.000	-0.0002	0.0000	0.000	-0.0013	0.0010	0.169
G2	0.00026	0.002	-0.0415	0.0224	0.065	0.0341	0.6726	0.960
G3	0.000576	0.000	0.0247	0.0271	0.362	-0.0090	0.8236	0.991
G4	0.000292	0.001	-0.0885	0.0277	0.001	-0.2499	0.8398	0.766
G5	0.000501	0.000	-0.0097	0.0204	0.635	-0.2193	0.6034	0.716
G6	0.000493	0.000	-0.0300	0.0245	0.222	0.7062	0.7399	0.340
G7	0.00065	0.000	-0.0343	0.0256	0.180	-0.0379	0.7471	0.960
G8	0.000294	0.001	-0.0081	0.0218	0.711	0.6618	0.6462	0.306
G9	0.000302	0.001	-0.0902	0.0345	0.009	-0.8684	1.0564	0.411
G10	0.000367	0.000	-0.0468	0.0474	0.324	-1.7536	1.4715	0.234
G11	0.000418	0.000	-0.0118	0.0224	0.598	0.0601	0.6699	0.929
G12	0.000364	0.000	-0.0229	0.0241	0.342	0.3753	0.7186	0.602
G14	0.000368	0.000	-0.0536	0.0770	0.486	-1.2163	2.4007	0.613
G19	0.000524	0.000	-0.0786	0.0859	0.360	-2.4500	2.6783	0.361
G20	0.000254	0.003	-0.0064	0.0227	0.777	0.3032	0.6807	0.656
G21	0.000177	0.036	0.0350	0.0372	0.348	0.5752	1.0880	0.597
G22	0.000557	0.000	0.0201	0.0302	0.507	1.0452	0.8689	0.229
G23	0.000806	0.000	-0.0202	0.0198	0.307	-0.0365	0.5857	0.950
G24	0.000754	0.000	-0.0205	0.0254	0.421	0.1468	0.7666	0.848
R ²	3%		2%			0.01%		

References

- Amatea, E.S., Cross, E.G., Clark, J.E., Bobby, C.L., 1986. Assessing the work and family role expectations of career-oriented men and women: the life role salience scales. *J. Marriage Family* 831–838.
- Anderson, D.R., Collins, P.A., Schmitt, K.L., Jacobvitz, R.S., 1996. Stressful life events and television viewing. *Commun. Res.* 23 (3), 243–260.
- Banton, M. (1965). *Roles: An introduction to the study of social relations* (Vol. 41): London, Tavistock.
- Benesch, C., 2012. An empirical analysis of the gender gap in news consumption. *J. Media Econ.* 25 (3), 147–167.
- Biddle, B.J., 1986. Recent developments in role theory. *Ann. Rev. Sociol.* 12 (1), 67–92.
- Blei, D.M., Ng, A.Y., Jordan, M.I., 2003. Latent dirichlet allocation. *J. Mach. Learn. Res.* 3 (Jan), 993–1022.
- Boczkowski, P.J., 2010. The consumption of online news at work: making sense of emerging phenomena and rethinking existing concepts. *Inform. Commun. Soc.* 13 (4), 470–484.
- Bogart, L., 1989. *Press and Public: Who Reads What, When, Where, and Why in American Newspapers*. Psychology Press.
- Burton, L.M., 1996. Age norms, the timing of family role transitions, and intergenerational caregiving among aging African American women. *Gerontologist* 36 (2), 199–208.
- Callero, P.L., 1985. Role-identity salience. *Social Psychol. Quart.* 203–215.
- Chaffee, S.H., Choe, S.Y., 1981. Newspaper reading in longitudinal perspective: beyond structural constraints. *J. Quart.* 58 (2), 201–211.
- Chaffee, S.H., McLeod, J.M., Atkin, C.K., 1971. Parental influences on adolescent media use. *Am. Behav. Sci.* 14 (3), 323–340.
- Chaffee, S. H., McLeod, J. M., & Wackman, D. B. (1973). Family communication patterns and adolescent political participation. *Socialization to politics: A reader*, 349–364.
- Chakraborty, A., Sarkar, R., Mrigen, A., & Ganguly, N. (2017). Tabloids in the era of social media? understanding the production and consumption of clickbaits in twitter. *Proceedings of the ACM on Human-Computer Interaction*, 1(CSCW), 1–21.
- Chan, J.K., Leung, L., 2005. Lifestyles, reliance on traditional news media and online news adoption. *New Media Society* 7 (3), 357–382.
- Daly, K., 1987. Discrimination in the criminal courts: family, gender, and the problem of equal treatment. *Soc. Forces* 66 (1), 152–175.
- DiMaggio, P., Nag, M., Blei, D., 2013. Exploiting affinities between topic modeling and the sociological perspective on culture: application to newspaper coverage of US government arts funding. *Poetics* 41 (6), 570–606.
- Edgerly, S., Thorson, K., Thorson, E., Vraga, E. K., & Bode, L. (2018). Do parents still model news consumption? Socializing news use among adolescents in a multi-device world. *new media & society*, 20(4), 1263–1281.
- Elzinga, C.H., Liefbroer, A.C., 2007. De-standardization of family-life trajectories of young adults: a cross-national comparison using sequence analysis. *Eur. J. Population* 23 (3–4), 225–250.
- Frisson, V.A., 2000. ICTs in the rush hour of life. *Inform. Society* 16 (1), 65–75.
- Haddon, L., 2000. Social exclusion and information and communication technologies: Lessons from studies of single parents and the young elderly. *New Media Society* 2 (4), 387–406.
- Karlsson, M.B., 2016. Goodbye politics, hello lifestyle. Changing news topics in tabloid, quality and local newspaper websites in the UK and Sweden from 2002 to 2012. *Observatorio (OBS*)* 10 (4) 150page-165.
- Knobloch Westerwick, S., Alter, S., 2007. The gender news use divide: Americans' sex-typed selective exposure to online news topics. *J. Commun.* 57 (4), 739–758.
- LaRose, R., 2010. The problem of media habits. *Commun. Theory* 20 (2), 194–222.
- Li, Z., Wang, W., Xu, T., Zhong, X., Li, X. Y., Liu, Y., ... & Zhao, B. Y. (2016). Exploring cross-application cellular traffic optimization with baidu trafficguard. In 13th {USENIX} Symposium on Networked Systems Design and Implementation ({NSDI} 16) (pp. 61–76).
- Martin, C. L., & Halverson, C. F. (1987). The roles of cognition in sex role acquisition.
- McArtor, D.B., 2017. *Extending a Distance-Based Approach to Multivariate Multiple Regression*. University Of Notre Dame.
- McArtor, D.B., 2017. *Extending a Distance-Based Approach to Multivariate Multiple Regression*, University Of Notre Dame, Dissertation.
- McDevitt, M., Chaffee, S., 2000. Closing gaps in political communication and knowledge: Effects of a school intervention. *Commun. Res.* 27 (3), 259–292.

- Mead, G.H., 1964. *On Social Psychology*. University of Chicago Press, Chicago.
- Morley, D., 2005. *Family Television: Cultural Power and Domestic Leisure*. Routledge.
- Nathanson, A.I., 2015. Media and the family: reflections and future directions. *J. Children Media* 9 (1), 133–139.
- Nelson, J.L., Lei, R.F., 2018. The effect of digital platforms on news audience behavior. *Digital Journal*. 6 (5), 619–633.
- Palau-Sampio, D., 2016. Reference press metamorphosis in the digital context: clickbait and tabloid strategies in Elpais. *Com. Commun. Soc.* 29 (2).
- Peng, T.Q., Zhou, Y.X., Zhu, J.J.H., 2020. From filled to empty time intervals: Quantifying online behaviors with digital traces. *Commun. Methods Measur.* <https://doi.org/10.1080/19312458.2020.1812556>.
- Peng, T.Q., Zhu, J.J.H., 2020. Mobile phone use as sequential processes: From discrete behaviors to sessions of behaviors and trajectories of sessions. *J. Comput. Med. Commun.* 25 (2), 129–146.
- Picone, I., Courtois, C., Paulussen, S., 2015. When News is Everywhere: understanding participation, cross-mediality and mobility in journalism from a radical user perspective. *J. Pract.* 9 (1), 35–49.
- Pleck, J.H., 1977. The work-family role system. *Soc. Probl.* 24 (4), 417–427.
- Poole, M.S., 2007. Generalization in process theories of communication. *Commun. Meth. Measures* 1 (3), 181–190.
- Robinson, J.P., 1981. Television and leisure time: a new scenario. *J. Commun.* 31 (1), 120–130.
- Rosenstein, A.W., Grant, A.E., 1997. Reconceptualizing the role of habit: a new model of television audience activity. *J. Broadcast. Electron. Media* 41 (3), 324–344.
- Stryker, S., 1968. Identity salience and role performance: the relevance of symbolic interaction theory for family research. *J. Marriage Family* 558–564.
- Stone, G.C., Wetherington Jr, R.V., 1979. Confirming the newspaper reading habit. *J. Quarterly* 56 (3), 554–566.
- Studer, M., Ritschard, G., 2016. What matters in differences between life trajectories: a comparative review of sequence dissimilarity measures. *J. Royal Statist. Soc.: Series A (Statist. Soc.)* 179 (2), 481–511.
- Studer, M., Ritschard, G., Gabadinho, A., Müller, N.S., 2011. Discrepancy analysis of state sequences. *Sociol. Meth. Res.* 40 (3), 471–510.
- Taneja, H., Webster, J.G., Malthouse, E.C., Ksiazek, T.B., 2012. Media consumption across platforms: identifying user-defined repertoires. *New Media Soc.* 14 (6), 951–968.
- Tang, H., Xiao, S., Zhao, G., Xing, C., 2012. Traffic behaviors on the mobile Internet. *J. Convergence Inform. Technol.* 7 (7).
- Vettehen, P.H., Konig, R.P., Westerik, H., Beentjes, H., 2012. Explaining television choices: the influence of parents and partners. *Poetics* 40 (6), 565–585.
- Vojnovic, M., 2008. On mobile user behaviour patterns. Paper presented at the Communications, 2008 IEEE International Zurich Seminar.
- Webster, J. G., & Phalen, P. F. (1997). *The mass audience. Rediscovering the Dominant Model*, Mahwah/New Jersey. Google Scholar.
- Zhang, X., Ha, L., 2015. Time budget, news search time cost, and news media choice. *Time Society* 24 (2), 201–220.

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