From Age to Age: Key Gerontographics Contributions to Technology Adoption by Older Adults

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Abstract: Research conducted on the topic of new technologies and gerontechnology acceptance and adoption by older adults is in its early development and poses challenges regarding the wholistic understanding of older adults' technology adoption's drivers and barriers. This study aims at contributing to the understanding of technologies' relevance and usage by older adults with a high accuracy ascertainment and increased simplification and effectiveness, starting from the gerontographics segmentation. For doing so, the study interviewed 125 older adults from three countries: Romania, Slovenia and Cyprus. Our research categorized these older adults in to four gerontographics groups according to their reported psychological and physical well-being. We found significant differences in the actual usage: perceived usefulness, the ascribed meaning of technology and their acceptance and/or rejection of the new technologies by the four gerontechnologies. These findings emphasized that the relation of older adults with technology and the barriers which arose are differently experienced by segments with dissimilar physical and psychological well-being. Nevertheless, they constitute powerful evidence of the value of the gerontographics in conceptualizing, developing and marketing new technologies and gerontechnologies.

1 INTRODUCTION

The aging of the population has led to an older adults' market where various business opportunities have arisen and attracted investment in technologies of health and medical care, insurance, entertainment and education for older adults. Hence, recent developments show that older adults are no longer seen as a supplementary market. They are seen as belonging to a large group with various abilities, needs and preferences which the technology industry is seeking to meet. Our study aims at contributing to meet these needs through a simple and effective model of technology acceptance for older adults.

Data show that older adults' technology acceptance and usage is still slow and lags behind expectations (Wildenbos, 2019; Friemel, 2016; Ramón-Jerónimo et al, 2013), although older adults are today more prepared to adopt to new technology because of the technology familiarity and pre-retirement computer use. Motivational indifference or the lack of relevance and deficient knowledge are at the core of technology rejection or limited use of technology, while cost is not a key factor anymore (Peacock, 2007; Juznic, 2006). An in-depth understanding of adoption or rejection of the new technology by older adults, the barriers and facilitating factors, is becoming more and more important as the older adult population increases.

For a deeper understanding of the factors affecting technology adoption or rejection by older adults, researchers and professionals started to refer to the now classic 'technology acceptance models' and to generate and tailor-made new ones based on specific technologies, i.e. internet, mobile phones (Macedo, 2017; Arenas Gaitán et al, 2015; Golant, 2017; Mitzner et al, 2010). Currently, a universal, accurate, effective and easy to apply understanding for technology acceptance for older adults is needed to accelerate technology marketing and further our understanding of the relationship between technology and late adulthood.

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We developed a new understanding while conducting three pilot cycles within the project Senior-TV (see acknowledgements). The sample project aimed at developing a platform for providing formal and informal care giving services to older adult citizens that live alone and that focuses on the active prevention and the maintenance of relationships with friends, family, and the community. The previous two pilot cycles were constructed on the TAM and UTAUT models and the research results show that there is a sharp difference in the technology adoption between the dependent and independent older adults and that the last tend to reject many of the gerontechnologies because of age-stigmatizing. The third pilot cycle, whose results are presented here, aimed at developing a new model for an in-depth understanding of the elderly adoption and actual usage of new technologies.

This new understanding can inform and support the introducing of new technology and gerontechnology in a gradual way, in order to support a progressive familiarity with technology along the diversifying of their needs with age. For example, the projects Ella4Life aims at offering a new technological solution adapted for people in various stages of their life, thus being customized to the specific issues of each group; from younger customers (55+) at risk of loneliness, sedentary behaviour and loss of independency, or with a desire or need for extra comfort or safety (because of slight physical or cognitive abilities) and moving to elderly customers / patients (70+) with slight to moderate and then moderate to severe diminishing of their physical or cognitive abilities. iCan is an inclusive online platform that will aid its users in various ways in their everyday life. How the iCan Solution can be accepted by the elderly aged over 70 years in order to increase their self-dependency and management is a challenge, especially for the countries whose cultures do not encourage preventive approaches in health and life styles. Therefore, these research findings are of great relevance for the Ella4Life and iCan mentioned projects for learning about how to increase acceptances and actual usage of the new technologies.

The present study shed light on the intriguing phenomenon of technology adoption through emphasizing the diversity of older adults and their relation with technology not through the lens of age, but through the inherent features of late adulthood in order to understand barriers and facilitators to technology acceptance. Age per se deceives research for that it may induce over-comparativeness to other younger groups, by emphasizing the have nots of the older adults rather than their needs, habits and preferences. The constant comparison with the younger generations may limit the understanding of the specific needs, wants and preferences of the older adults and refrain research from studying the diversity within the older adults' group.

2 THEORETICAL BACKGROUND

The category stereotyping of 'older adults' drives industry, decision makers and others to think about older adults as being a homogeneous group in needs and preferences, which, it is not. Older adults are a more diverse group than younger generations because their differences and diversity have increased with age. And older adults' attitudes towards old and new technology are also heterogeneous (e.g. age, culture, emotional state of health, cognitive abilities). Therefore, an age-based definition of the older adults or the distinction between young and older adults is of insufficient use-effectiveness (Nimrod, 2013; Sthienrapapayut et al, 2018). The lack of the true understanding of the make-up of the older adults' market coupled with the lack of experience in working with and for older adults also prompts older adults to reject modern technology for that that does not respond to their call.

Age matters but it does not decide on technology acceptance (Moschis 2019; Paul et al 2019; Steenstra 2015). There is invariable some decline which comes with ageing, but large variance remains within the group. For example, somebody at 65 years old may exhibit the same state of health as somebody at 75 years old and vice-versa. Mallenius et al. (2007) suggest functional capacity, referring to the physical, psychological and social aspects as factors which facilitates technology adoption. Sharit, et al, 2009) show that chronological age can be replaced by variables such as cognitive abilities and knowledge when predicting information seeking on the internet by older adults. McCloskey (2008) found that age does not significantly affect the perception of usefulness and it may have an indirect effect on the technology acceptance through ease of use.

Gerontographics suggest that rather than considering age per se, more accurate and relevant data are to be obtained when accounting for physical and psychological state of the older adults.

Geronthographics is an approach developed by Moschis (1996) and it is employed in marketing and consumer behaviour. It proved to be

extremely efficient in predicting older adults' consumer activity or, going beyond the trite understanding of the concepts of biological and cognitive age (Nimrod, 2013; Sthienrapapayut et al, 2018). It aims at revealing the individual differences in aging processes in late life in all respects and it assumes that these differences are the outcome of 1) The individual differences in ageing, and 2) the variances in the life experiences which influence psychographics factors. According to Moschis, the life experiences of the older adults' influence on the psychological factors, which ultimately, influence their needs and wants.

Moschis refers to four categories of older adults which are selected based on their state of health on a continuum from independency towards dependency, as healthy indulgers, ailing out goers, healthy hermits and frail recluses (Moschis and Mathur 1993; Moschis 1996, 2003;). The approach is based on the assumption that older adults manifest similar behaviour consumer activity as long as they had encountered similar circumstances, experiences and past events, based on the type of aging experience. The first group are those people who exhibit physical and psychological wellbeing and adapted well to life's challenges. Their good health conditions support their psychological and social aging. The second group is still independent and socially active in spite of a decline in health. Against their low-level of physical well-being, they manifest a high-level of psychological well-being. The third group are those who present a quite well health condition, but due to the accumulated experiences of negative encounters, they insulate themselves socially and "feel" being old. Hence, they are those who have a quite good physical well-being but a low psychological well-being. The fourth group are people with chronic health conditions and who encountered negative life events. They show a relatively low physical and psychological well-being alike.

Because we considered the terms ascribed by Moschis derogatory, such as frail recluses or healthy hermits, we will further use the four categories without name reference: 1) the first group, those in good health and active, ph+ps+ (physically and psychologically well), 2) the second group, those in poor health and active, ph-ps+ (physically not well but psychologically well), 3) the third group, those in good health but without a social life, ph+ps- (physically well but psychologically not well), and 4) the fourth group, those bound due to poor health, ph-ps- (physically and psychologically not well).

The four categories better reveal why some technologies are adopted while others are rejected by older adults. Some technologies are meant to serve a medical or utility purpose, while some other are designed for more hedonistic experiences. But utility and hedonism or information and entertainment have different meanings to people based on their state of health and irrespective of their age. For example, active and independent older adults do not perceive Health Technologies and Gerontechnologies to be useful for them and prefer to adopt technologies of a more universal use (Spiru et al; 2019). Arning and Ziefle (2007) found that older adult users do not take into account the time and effectiveness of the new technologies but they put value on the results.

3 TECHNOLOGY ACCEPTANCE MODELS

For understanding technology acceptance by older adults, research employs either the classic models largely deployed for adult working population and for youth (Venkatesh et al, 2003; Venkatesh et al., 2012) or those developed especially for older adults. The first refer to 'Technology Acceptance Model' (TAM) and 'Unified Theory of Acceptance and the Use of Technology' (UTAUT and UTAUT2) (Guner and Acarturk, 2020; Macedo, 2017) while the second refer to The Senior Technology Acceptance Model (STAM), which was proposed by Renaud and Biljon (2008) and the Gerontechnology Acceptance Model proposed by Chen and Chan (2013).

The models' limit is seen in inspecting into the 'Behavioural Intention to Use' without inquiring into the 'Actual Usage' (Bouwhuis et al, 2008) as the 'Perceived Usefulness' does not equal adoption. They proved insufficiently relevant due to the specific characteristics of older adults and of limited relevance due to the fact that they have been tested on specific technologies, i.e. mobile phone adoption (Renaud and Van Biljon, 2008). More, some studies refer to older adults as 'people over 55', which increases the heterogeneity within the old aged group and affects the findings with respect to the levels of adoption and effective usage of new technologies (Arenas Gaitán et al, 2015).

The models so far developed are complex, cost timing, and require sophisticated proficiency for interpretation. All these constitute barriers for the researchers to scale the models or for the marketers

to endorse these models, when new technologies and gerontechnologies are to be tested.

4 METHODOLOGY

We employed a survey methodology because this approach affords the comparative analysis among the four gerontographics groups providing insight into the details of actual usage and the perceived meanings associated to technology, hence 'perceived usefulness'. This study was not aiming at testing models of technology acceptance (e.g. TAM), but to contribute to a better understanding of what is 'perceived usefulness' for each of the four gerontographic groups. The central question was 'Are technologies ascribed different meanings based on individual factors or do they hold different meanings based on the groups characteristics?'

The study was based on a survey conducted in Romania, Cyprus and Slovenia over the course of February and April, 2019. The end-users survey had a convenient sample of members. The sample size is moderate, comparative to those samples which served as basis for the studies conducted by (Ma et al., 2016; Li et al 2018).

In order to recruit participants, the project coordinator of each country contacted the administrators of nursing homes, day centers, hospitals and retirement homes and older adults at home and asked for their permission to test the Senior TV product. All study participants provided informed consent.

In the case of Romania, out of the 52 respondents, 20 withdrew from the trial section. There were two main motivations for the high drop-out rates: 1) the perception of an intrusive nature of the testing, as the Senior-TV device needed to be installed on their own private television set and the testing should have been placed in their own homes and 2) the irrelevance of the product to their current interests and lifestyle.

Members' physical and psychological wellbeing is estimated by asking respondents to answer to the short version of the Health Survey (SF12), a scale to indicate the physical and psychological state of the respondents, and which ultimately led us to employ the gerontograhics segmentation. We have included the "Verbal Fluency Test" (VFT) which is an instrument for cognitive assessment that was administrated at the very beginning of the testing period by the field-operators along SF12.

The third cycle pilot included a total of 125 primary end-users who were distributed as following: 52 from Romania, 30 from Cyprus and 43 from Slovenia. Chi-square tests of homogeneity were conducted to determine if there were significant differences between category frequencies. For the case of Romania, there were 52 older adults pre-trial interviewed and the drop-out rate was of 20 seniors. One third of the older adults were living at home independently, while the rest were residing in nursing homes and sanatoriums. The 125 respondents were 57-90 years old, and the average was 73, while the most frequent age was 70. The third group, physically well but psychologically not well (ph+ps-), constituted the largest group among the sample, comprising 49% of respondents. Half of them live in Slovenia and the other half is equally distributed across Romania and Cyprus. The first group (ph+ps+) accounted for 15% of the sample and they are the older adults at home who have been interviewed in Romania. The fourth group, those physically and psychologically not well, ph-ps- (30%) are equally distributed across Romania, Cyprus and Slovenia. The smallest group, (6 persons) are those physically not well, but psychologically well, ph-ps+.

5 RESULTS

Our research shows a clear distinction between the early usage of technology of the now older adults, which indicates that the current actual usage of technology is much dependent on the 'relevance' or 'perceived usefulness' that is ascribed to a specific technology. Older adults who are now psychologically well, encountered much earlier the four main technologies which radically changed information access, communication and entertainment at a global scale: TV, Mobile, Computer and Internet, comparative to the two categories of older adults who are not psychologically well.

These last two categories encounter technologies such as computer and internet, on average, with between 10 and 25 years later. Their late interest in technologies runs counter to the popular narrative of an existence of a negative relationship between age per se and technology usage.

The results also emphasize that the current usage of technology does not depend on the starting age of using technology, as the ageing process may change the habits of usage of various technologies.

With respect to the 'actual usage', sharp differences are noted among the four categories coupled as those who do psychologically well (ps+ph+ and ps+ph-) and those who do not (ps-ph+

and ps-ps-) in using the TV services. The below table shows that none of those who are psychologically well use any of these TV services. Research findings clearly indicates that for older adults not psychologically well, there is a high incidence of usage of TV Smart Application (Pearson R=.484) and also high correlations for the cases of TV Images (Pearson's R=.369).

We inquired if each of the four gerontographics groups ascribe different meanings or 'perceived usefulness' to technology. We noticed that watching TV does not share many mentally associations for those psychologically well, while there are plenty of mentally associations attributed to TV watching by those psychologically not well, irrespective of their physical state, as shown in table 1.

If information and social integration, along enjoyment prevail for the first two categories who are psychological well, the last two categories who are not psychologically well associate TV watching with decreasing loneliness and companionship to a high degree. From those in good health and active (ps+ph+) the majority (62.5%) and the many of them (42.9%) appreciate TV for 'Information' and 'Social Integration', respectively. Those in poor health and active (ps+ph-) along 'Information' (66.7%) and 'Social Integration' (50%) also appreciate 'Enjoyment' (66.7%).

Notable differences may be found also among the last two categories, which need to be accounted by the technology developers, designers and marketers: those in good health but without a social life, ps-ph+ and thouse bound due to poor health (ps-ph-). If the overwhelming majority of those in good health but without a social life associate TV watching with decreasing loneliness (83.6%) while also looking for information (80.3%), those who are bound due to poor health look first for enjoyment (89.5%) and decreasing loneliness (76.5%)and companionship equally (75%).

Nevertheless, TV watching is associated with 'Social Integration', which matters for each category of older adults, though it increases in significance from those independent to those dependent, namely form those socially active who also have other means for social integration to those who lack that (42.9% to 60.6%) TV maybe being the only or one of avery few vehicles for their sense of belonging to society after retirement.

Table 1: The most frequent age of starting to use technologies based on the gerontographics segmentation.

	ph+ps+ (most frequent age)	ph-ps+ (most frequent age	ph+ps- (most frequent age)	ph-ps- (most frequent age)
Started Watching TV	10 yrs	25 yrs	20 yrs	15 yrs
Started Phoning from Mobile	50 yrs	50 yrs	60 yrs	60 yrs
Started Accessing Computer	40 yrs	45 yrs	60 yrs	65 yrs
Started Navigating on Internet	60 yrs	45 yrs	70 yrs	65 yrs

Table 2: The actual use of new technologies for Tv from a Gerontographics Perspective.

	Radio on TV	Teletext on TV	SmartApp on TV	TV Images on TV	TV Video on TV
ph-ps-	7.7%	20.5%	69.2%	56.4%	43.3%
ph+ps-	16.1%	16.1%	71.4%	51.8%	37.5%
ph-ps+	0.0%	0.0%	0.0%	0.0%	0.0%
ph+ps+	0.0%	0.0%	0.0%	0.0%	0.0%

Table 3: The associations of meaning of TV watching based on the gerontographics segmentation.

	Information	Enjoyment	Decrease loneliness	Companionship	Social integration	Ritual
ph+ps-	62.5%	37.5%	18.8%	31.3%	42.9%	36.0%
ph-ps+	66.7%	66.7%	16.7%	33.4%	50.0%	-
ph+ps-	80.3%	54.5%	83.6%	52.8%	57.7%	61.5%
ph-ps-	72.9%	89.5%	76.5%	75.0%	60.6%	48.6%

Table 4: The Relation between the Gerontographics Segmentation and the Perceived Usefulness and Social Influence Variable in the Framework of Gerontographics Technology Adoption by Older Adults (G-TAO).

	The actual usage of new technologies related to Tv	Perceived Usefulness/ Social Influence
ph±ps+	1.No usage 2.No predisposition for new technologies 3.Watching TV Meaning: Information & Enjoyment (strong emphasis on Enjoyment for ph-ps+)	1. Perceived usefulness: New Information (No redundancy of TV, smart phones &Internet Services) 2. Perceived usefulness: New Information & Enjoyment
ph+ps-	1. Diverse usage of the new technologies 2. Predisposition for new technologies 3. Watching TV Meaning: Information, Decrease loneliness & Ritual	1.secondary beneficiaries/ Informal carers
ph-ps-	1. Diverse usage of TV Services 2. Predisposition for new technologies 3.Watching TV meaning: Enjoyment, Decrease Loneliness, Companionship, Information & Social Integration	1 nursing professionals 2.Secondary beneficiaries support

What made some of the older adults to explore a new technology and prevent others from a new technology experience in spite of their openness to participate into the study? In our research, the dropout rates occurred only for the older adults psychologically well, which indicate that the 'Perceived Usefulness' (PU) is key for these 2 categories (physically well or unwell, while psychologically well). The 'Perceived Usefulness' gives the incentive towards the exploration and experimentation stage, which afterwards confirm or infirm the 'Perceived Usefulness' of the product or service and, in the end, it translates into the acceptation or rejection of the new technologies. That confirms the results presented by Moschis (2003; 2019) which show that independent seniors avoid opting for gerontechnologies and any technology services which age-stigmatize, preferring to opt instead for universal technologies. Our research shows that for the case of the older adults bound due to poor health (ps-ph-), the 'Perceived Usefulness' variable is not of relevance, as they are influenced by

formal and informal carers in their openness towards new technologies and gerontechnologies exploration and adoption. The situation of the group in good health but without a social life (ps-ph+) is similar, as they are influenced by their informal entourage, more specifically by their relatives or informal carers.

Social Influence (SI) stays for the degree to which an individual believes that what others feel if he or she should use a particular technology and it has been identified as a relevant factor in accepting technology (Or and Karsh, 2009; Venkatesh et al., 2003; Thompson et al., 1991; Lee, 2007; Mallenius et al., 2007). We have found that social influence matters only with respect to older adults who are psychologically unwell, for the groups ph+/- ps -. Therefore, 'Social Influence' (SI) is considered here in tandem with 'Perceived Usefulness.

The table above presents the detailed explanation of the findings and summarizes the relation of each gerontographics category with technology, the predisposition and the perceived usefulness for older

adults psychologically well, or social influences for older adults psychologically unwell, in the case of new technologies. 'Social Influence' and 'Perceived Usefulness' should not be considered as predictors per se, but based on the gerontographics differentiation, these variables should apply to older adults based on the degree of (in)dependency.

6 DISCUSSION

The sharp differences between the two categories psychologically well and the two categories psychologically not well, shows us that 1) the last two categories, those who are psychological not well, are the target market for new technologies and gerontechnologies. In spite of their chronological age, they manifest a late interest in technology predisposition and usage, which is not shared by the other two categories in their old adulthood. Their late interest in technologies runs counter to the popular narrative of an existence of a negative relationship between age per se and technology usage; 2) the current usage of technology does not depend on the starting age of using technology, as the ageing process changes the habits of usage of various technologies. An explanation for that might be that those psychologically well, irrespective of their current physical state, encounter technology in their professional and social life prior to retirement. For those older adults, the life changes which occur after retirement decrease the necessity for technology adoption. On the contrary to that, those psychologically not well have a decreased interest in the newness of technology prior to retirement but, when their life after retirement radically change into more isolation and loneliness, their interest in technology increases as technology becomes the only source for meeting social and personal basic needs; 3) we are also entitled to hypothesized that the predisposition of using technology might be an early indicator or predictor of the state of health and of the gerontographics type of the individual ageing process.

Our study found that access to information is of value to the older adults who are physically and psychologically well, while all the other value technologies which support them in decreasing loneliness, ritual, companionship or enjoyment.

Those who are psychologically well do not use anymore the old technologies and have a limited adoption of new technologies. They started the relation with mobile, computer and internet earlier on average but did not continue to endorse new technology after retirement. We found that the first reason for the limited relevance of new technologies for older adults psychologically well is the redundancy or duplication of services in communication, information and others, such as agenda, video-call, alarm notifications, weather, news or health monitoring and information. Therefore, when conceptualizing new technologies which target older adults their participation in the project idea development is as important as their participation in the design of the project.

The Older adults Technology Adoption Model Revisited. Our aim was to advance a new model for technology adoption by older adults which is simplified comparative to the existent models and which has a better prediction power. We adapted the most frequent theoretical models and validated a new universal comprehensive understanding for older adults' technology adoption, starting from the gerontographics segmentation. Gerontographics gave us a more in-depth understanding of the relation between the older adults' technology habits and the predisposition towards the usage of new technologies or gerontechnologies. Our contribution refers to the already mentioned two conceptual models designed for older adults. We found that in the case of older adults psychologically well, the 'Perceived Usefulness' of a new technology determines the acceptance or rejection of a technology, while in the case of those psychologically unwell, the influence of the formal and/or informal caregivers is decisive. Once that the technology is accepted, the perceived ease of use will lead to the adoption or rejection of that technology, though that might preserve a limited usage of the technology in case, based on the relevance of that technology ascribed in one's life. The ascribed relevance is a dynamic process which change in time in close relation with the physical and psychological individual changes.

Based on the research findings, both E4L and iCan projects would learn how to enter into the silver market. The new technologies should target those psychologically well differently from those psychologically not well, who will be actually targeted through their informal carers. Those physically and psychologically well will opt for new technological solutions as long as these avoid age-stigmatizing and emphasize on the added value of informational aspects, which give them the 'perceived usefulness'. For those physically not well, but still psychologically well, entertainment along information is of equal value. Those psychologically not well have a predisposition towards new technologies in the sense that they expect from them
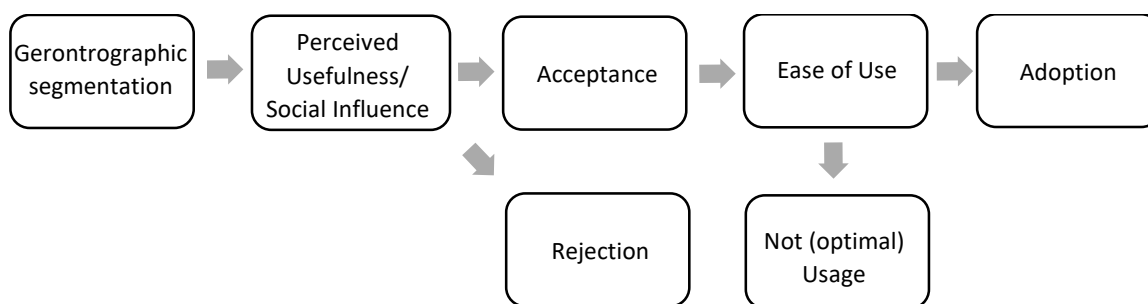
Figure 1: The Framework of Gerontographics Technology Adoption by Older Adults (G-TAO).

companionship, to ritualize their day and to increase their sense of being socially integrated. Though, their formal and informal carers much influence their perceived usefulness and decision in the adoption of new technologies.

In conclusion, this is, to our knowledge, the first study which inquires and considers the mentally ascribed meanings of technology as factors influencing the acceptance of technology. The high diversity of the older adult population, the variety of their unmet needs and motivations (Valk et al 2018; Golant, 2017; Schomakers et al 2018) need to be accounted for when proposing new technologies and gerontechnologies to older adults.

Our findings are valuable for their increased simplification and effectiveness due to the employment of gerontographics segmentation. Our model shows that the relation of older adults with technology and the barriers which arose are differently experienced by segments with dissimilar physical and psychological well-being and support the value of the gerontographics in conceptualizing, developing and marketing new technologies and gerontechnologies to the older adult population.

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