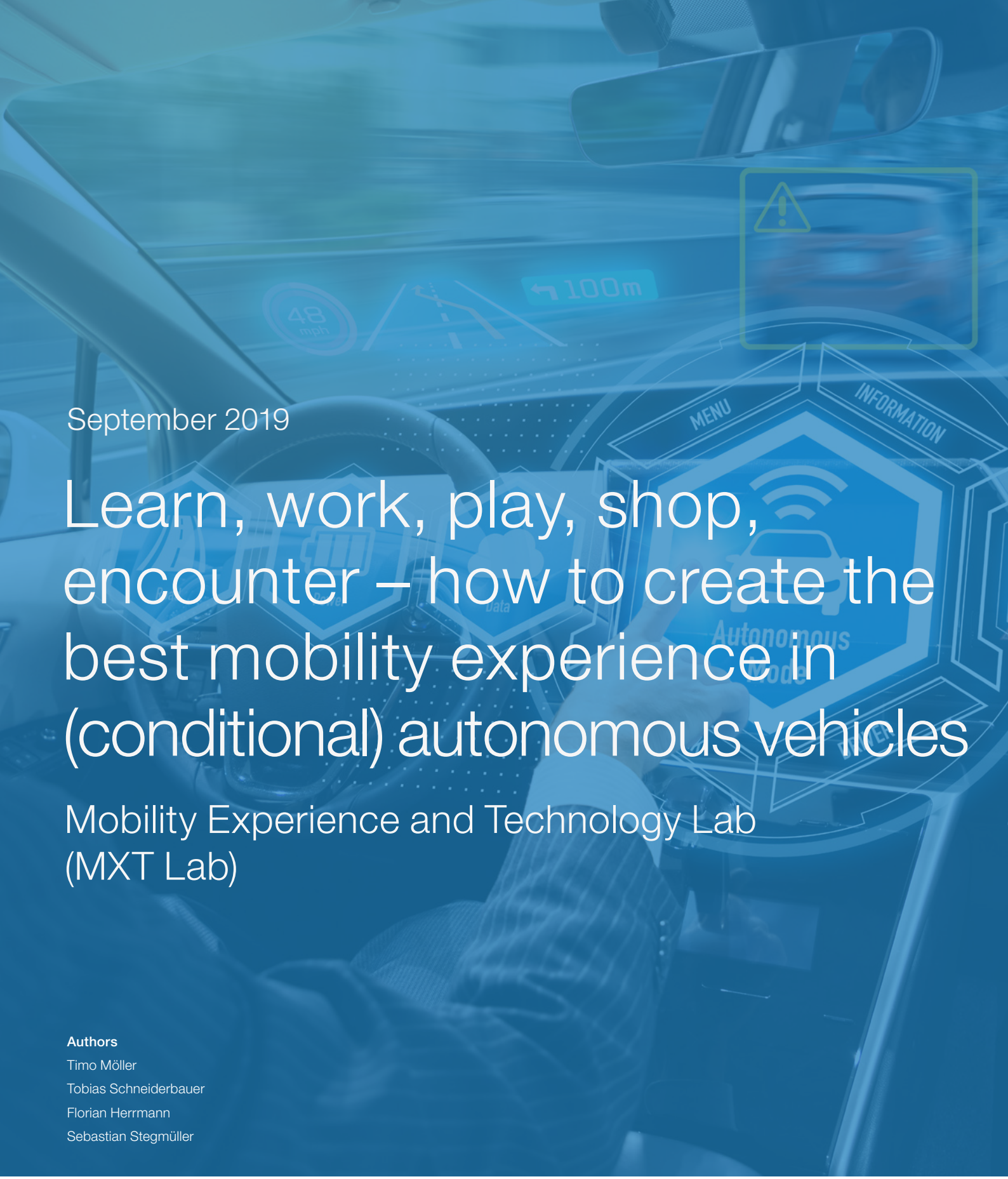

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Learn, work, play, shop, encounter – how to create the best mobility experience in (conditional) autonomous vehicles

Mobility Experience and Technology Lab (MXT Lab)

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The Mobility Experience and Technology Lab helps companies innovate via proven, highly creative research approaches.

Today's harried commuter will soon have a lot more time on his or her hands. That's good news for drivers, according to the Mobility Experience and Technology Lab (MXT Lab), established by the McKinsey Center for Future Mobility and the Fraunhofer Institute for Industrial Engineering IAO.[1] A working laboratory located in Stuttgart, the MXT Lab features a broad network of partners that can help players from the automotive sector and beyond, such as mobility-as-a-service (MaaS) providers and service and content providers, navigate their way through crucial aspects of mobility experience.

The MXT Lab hosts roundtables enabling companies to discuss ideas and actively tackle the challenges and opportunities of a fully connected and increasingly autonomous future. It employs breakthrough research prototyping methods and tools, and provides space for an ecosystem of mobility players to collaborate, develop and test new Mobility Experience (MX) ideas in an environment that enables rapid iterations. Normally, ideas formulated during early R&D stages typically receive only rudimentary evaluations, as companies rely heavily on theoretical ideas and documents and abstract evaluations to make decisions. While they may support new developments with consumer surveys, most usually fail to apply integrated and holistic user-centered evaluation techniques.

The Lab's multifunctional space combines a broad range of innovative methods and technologies to develop and evaluate future MX ideas and offerings. The goal is to bring everyone to the table – not just the two partners developing a given application. Instead, all stakeholders engage each other to find new synergies, and they can do it much more rapidly than general collaboration procedures would allow. Furthermore, they can benefit from our user-centered research methods and business understanding to pursue a more integrated approach.

Exploiting in-car connectivity

The MXT Lab predicts that just about a decade from now, the typical car ride will be dramatically different from today's. As passengers in autonomous vehicles (AVs), consumers could access the car's connectivity and computing power to pursue a much more active and satisfying use of their time. Options might include learning a foreign language, working, gaming, shopping, or participating in other experiences, all aided by specific software and technologies.

McKinsey's ACES survey[2] notes that about 70 percent of users express an openness to spending this newly available time actively participating in these new mobility experiences. In line with this finding, users increasingly expect to access applications and

1 The Fraunhofer Institute for Industrial Engineering IAO is part of the Fraunhofer Gesellschaft, Europe's largest application-oriented research organization.

2 ACES focuses on AVs, car connectivity, electrification, and smart mobility.

content all the time – including in their vehicles. In fact, the in-car connectivity experience is already such an important differentiating factor that 40 percent of consumers globally would change their brand of vehicle for better connectivity features.

Opening the (car) door to new experiences

Today, digital devices provide a portal to the mobile world. Soon, the human/machine interfaces (HMI) developed by automotive players will compete with those developed by the mobile communications industry for customer attention, since traveling in a self-driving car will be "hands free."

By 2030, we believe car-focused, data-driven and connected applications can create a revenue pool of more than USD 200 billion. This value will result from the proliferation of greater connectivity in vehicles. Innovations have not stopped at the car door, either. As recent studies show, users like the ability to integrate their mobile devices and connected services seamlessly into their vehicles.

While still embryonic, this market has huge potential and offers many new possibilities. To crack it, players need a clear, customer-centric approach, a concrete implementation strategy enabled by a secured digital and legal platform, the right organizational model, and the right complementary partner.

Bringing attractive offerings to life

Some leading automotive and mobility players have already begun to make distinctions between today's preoccupied drivers or inactive passengers and tomorrow's AV occupants, recognizing them as potential users of multiple devices and applications. Consequently, tomorrow's in-car mobility experience offerings will compete with a much broader set of activities and devices than before – and companies in this space will need to entice users with innovative solutions to gain their attention.

This will represent a huge and attractive market in the future. Mobility players that provide these new solutions and customer experiences can tap into additional sources of revenue based on generating and analyzing valuable, directly collected, and controllable data on customer behavior.

Developing these new mobility experience offerings will be difficult for incumbent players. Here's why: the Mobility Experience (MX) product-service systems will rely on different technologies, services, and applications, with the goal of providing innovative, user-oriented solutions that require an integrated understanding of mobility and digital product experience. MX offerings will use the latest achievements in connectivity and related fields, requiring know-how and skillsets that traditional automotive players often do not possess on their

own. Instead, incumbents will need capabilities, products, and services from other industries. The latter will also require joint innovation approaches that generate symbiotic business models for OEM, service providers and others.

What's more, McKinsey estimates that an automaker must invest about USD 70 billion over the next decade to ensure their leadership on all four ACES disruptions. Even for globally scaled auto companies, this huge sum will be very difficult for any single player to shoulder alone, given all the other expenditures they face. Instead, companies will likely require collaborators and new partnerships. It's also very likely customer relationships will change, with service providers and non-native mobility providers taking stronger positions and interacting directly with customers (as opposed to OEMs), further stressing the need for partnerships.

A five-step process to adopt concrete user-centered implementation plans

Identifying and evaluating future MX offerings for connected and autonomous vehicles requires holistic, user-centered research and innovation processes and more sophisticated approaches to ideation and product/service development. While manufacturers have experience developing new hardware and vehicle-related software, most are far less familiar with products and services that address the wider ecosystem, or those concerning potential in-car use cases that will become more prevalent with the rise of AVs.

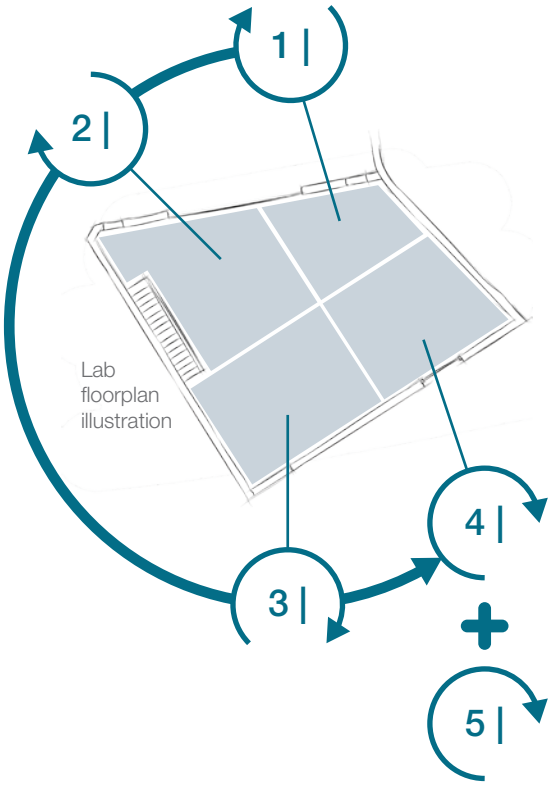
Innovations in this largely software-based field, with its much faster innovation cycles compared with traditional hardware and much tighter links to customers, require new methods and approaches. Many times, these include close collaboration and/or partnerships with new players.

Experience suggests companies often need help in taking a step beyond typical cooperative efforts. The MXT Lab creates a multifunctional space that combines a broad range of innovative methods and technologies to develop and evaluate future MX ideas and offerings. The goal is to bring everyone to the table – not just the two partners developing a certain application. Instead, all stakeholders can challenge each other, find new synergies, and create new innovative solutions. Most importantly, they can do it much faster compared to general collaboration procedures. Furthermore, they can benefit from our user-oriented research methods and business understanding to pursue a more integrated approach.

The MXT Lab addresses common challenges and shortcomings in typical R&D processes and decision making by adopting a brand-new research approach focused on five core mobility experience processes: ideation, creation, evaluation, conceptualization, and quantification.

Exhibit 1

The MXT Lab is a place for experiments, where early-stage MX ideas can be rapidly tested towards do-or-don't decisions



1 | Ideation

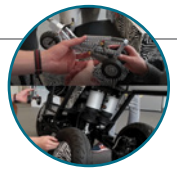
Room for analysis of future business models and mobility visions together with our experts, space for demo-meetings with potential partners

2 | Creation

Place for ideation workshops, make-athons, and meetings with tech players, content providers, and startups

3 | Evaluation

Laboratory for testing and quanti-fying customer perception of future Mobility Experience offerings in our highly flexible demonstrator and fast research ecosystem



4 | Conceptualization

Prototyping garage for rapid develop-ment of MVPs and digital applications in hackathons and design sprints, potentially together with our design partners Veryday and Lunar

5 | Quantification

Selective quantification and strategizing of promising ideas for MX offerings, bridge-build-ing to your research and development

1 | Ideation

Today, companies often perform ideation in silos with limited cross-functional interaction. It often takes place within individual divisions or business units and thus remains limited to their respective product or service scopes. Much of it is also redundant and sometimes even leads to confusion within a company. Furthermore, organizations rarely involve partners or customers in the process, thus limiting the ideation potential. In a world with greater connected mobility levels that involve more stakeholders and players than in the past, traditional methods will not be enough to ideate competitively.

The challenge today involves spanning collaboration opportunities beyond company borders and delivering ideas for innovative MX offerings that reflect the new levels of freedom AVs can provide. Acknowledging this change, the MXT Lab provider a unique research ecosystem across all fields of new mobility experience with access to many potential cooperation partners, experts, and start-ups. It offers a place for idea development and exchange that is much larger and more open than individual players could likely achieve on their own – enabling a broader and more innovative ideation process.

Autonomous driving offers high potential for the incumbent auto industry and opportunities for players offering non-automotive services. Big non-automotive players like Amazon, Spotify, and Apple have already begun to prepare for AV-inspired changes that could have an impact on their development processes. An example involves the recent cooperation of Intel and Warner Brothers, which seeks to provide an innovative entertainment AV travel experience. For instance, a concept vehicle outfitted by the two partners includes an immersive comic book viewing experience. Beyond these global players, several startups have also entered the mix.

Assessing the value of in-car language learning. Within the MXT Lab, ideation on potential in-car services in AVs has already surfaced numerous potential use cases. Since the (former) driver no longer needs to focus on driving and is free to experience the journey in a new way, these ideas include activities like reading, working, online shopping, or skill building. One of the potential skill-building ideas involves using this freed-up time and the controllable space of a vehicle for in-car language learning. We chose to focus on this rather unconventional skill-building activity instead of entertainment to emphasize the huge variety of potential in-car activities.

The ubiquity of mobile devices makes this trend possible: mobile-assisted language learning (MALL) becomes a spontaneous, personalized activity one can engage in virtually anywhere. The massive download rates of language-learning apps help to confirm this trend. For instance, programs such as Duolingo, Memrise, Babbel, and Busuu have millions of installations for Android users in the German market alone.

The rising demand for language-learning apps and the growing competition for new in-car services suggests language learning in an AV has high potential. The MXT Lab study gathered new insights regarding in-car language learning as it evaluated the potential of this use case.

2 | Creation

During a project's early stages, R&D decisions often primarily reflect only abstract ideas and back-of-the-envelope business models. Instead of rigorous research and analysis, choices emerge based on gut instinct and experience. In contrast, robust innovation processes result from a solid awareness of the needs of customers during the early stages of development. The integration of those requirements and interests can increase efficiency within the value chain, resulting in a product that will fully meet customer needs.

This co-creation process also helps companies overcome the "local search bias," where businesses typically stay within their industry's borders when innovating. While an organization must often contend with this kind of operational blindness, consumers can provide an impartial point of view that offers valuable insights and opinions regarding the innovation. The MXT Lab can help achieve significant innovation breakthroughs by routinely involving partners from other industries early in the process.

Products with true "outside of the box" characteristics like AVs tend to worsen the creation challenge because no comparable offerings exist in the marketplace that consumers assessing them can reference. Consequently, enabling hands-on experiences becomes highly relevant for customers as they explore an AV's potential. Gaining meaningful insights regarding potential new MX offerings thus involves early user and expert tests that require early-stage prototypes.

From "pretotypes" to prototypes. To enable this work, the MXT Lab offers a broad range of rapid techniques and tools for so-called "pretend prototypes" (pretotypes) and prototype development. Pretotypes enable the evaluation and observation of user behavior, and can identify the levels of acceptance of a product at significantly lower cost than actual prototypes. The idea is simple: spend time developing functions and understanding user interactions instead of focusing solely on technical solutions or design considerations.

The MXT Lab created a pretotype for in-car language learning. Constantly refined over a few weeks, the pretotypes enabled us to test all kinds of technologies, including virtual reality (VR), augmented reality (AR), and gesture and voice controls, each typically in just days. In-person user tests used a cockpit mockup to refine results and gather direct reactions. The pretotypes had simulated features such as the light source adjustments, vehicle and road noise settings, ride feel, display positioning (and possible movement), and the interactions between the consumer and the display screen. For example, the dashboard included a huge removeable display that demonstrators could position between the driver and the windshield.

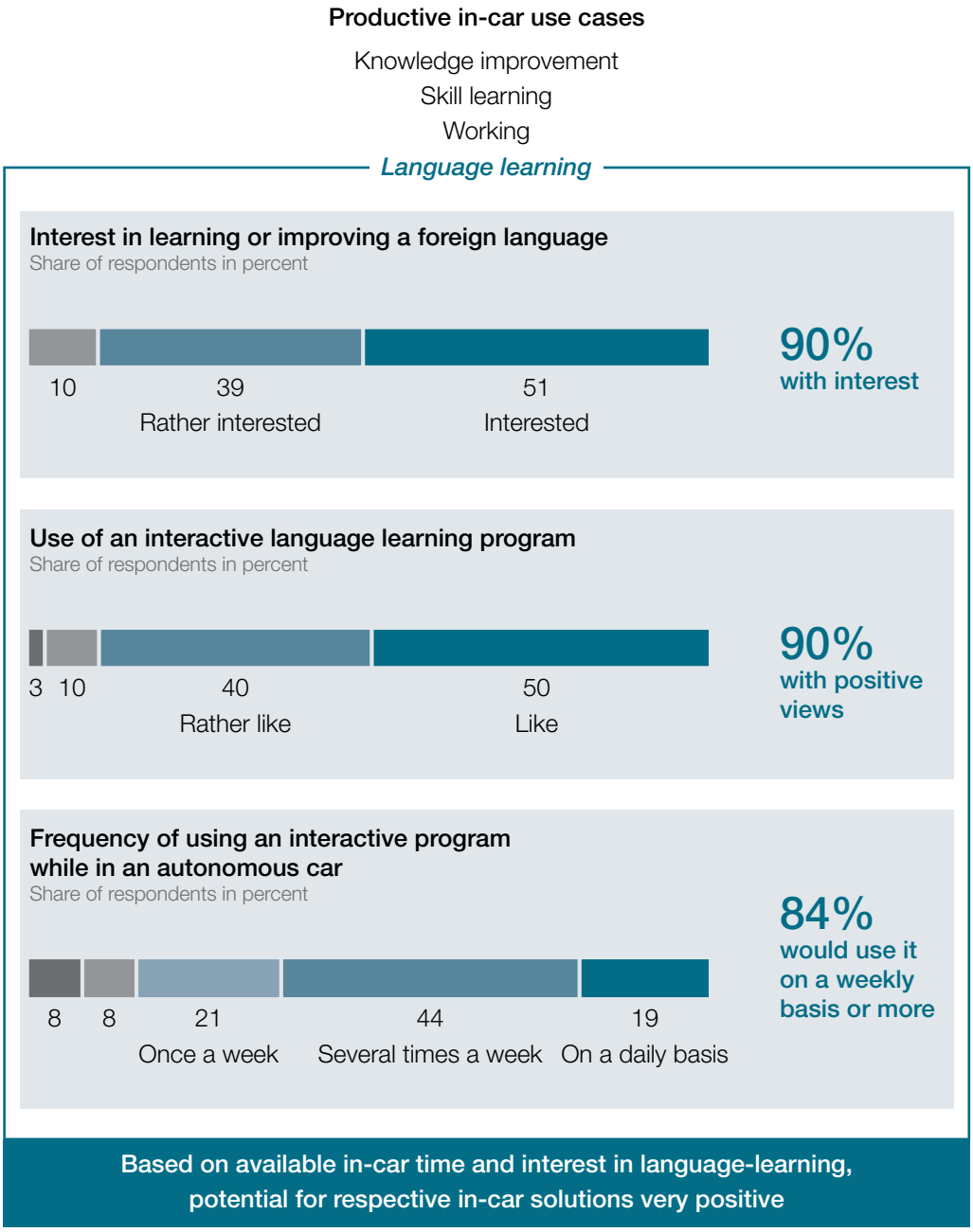
Involving the customer early on is key to develop solutions which are creating real value, currently we are not yet there in our organization

– Premium OEM

The study integrated touch, gesture, and voice commands, providing different interaction possibilities between customers and the pretotype. For instance, while a moderator was reading a story to the participants, support personnel in the back were adjusting respective features of an “in-car language-learning solution” in the vehicle.

Exhibit 2

Looking at potential use cases to support consumers desire of being productive, we have investigated attitudes towards in-car language in more detail



SOURCE: MXT Lab survey on in-car language learning; September 2018, n = 1,510

3 | Evaluation

The MXT Lab conducts an integrated evaluation of new ideas by combining multiple evaluation methods, including large-scale surveys and applied user tests and experiments. The Lab's network of partners from various industries (including automotive, technology, content-providers, insurance and many more) challenge and refine the evaluations. To evaluate the potential use case of in-car language learning, the Lab conducted a survey with approximately 1,500 international respondents in China, Germany, and the US.

About 90 percent of the survey respondents expressed interest in learning or improving their comprehension of a foreign language. What's more, a similar share stated they spend half or more of the time alone in their cars, providing them with a potentially great study opportunity.

Respondents viewed the vehicle as more than just a space where this instruction could occur when it contains an interactive learning program – a clear indicator that vehicle manufacturers and content providers need to collaborate more to capture this value.

Our study suggests the ideal in-car language experience should last between 10 and 40 minutes; a view expressed by 80 percent of respondents. However, this does not mean customers want to study any time that a drive potentially meets those criteria. Instead, a successful solution needs more nuanced trigger mechanisms to encourage learners to use it.

Connected to this finding, the Lab surveyed attitudes concerning features that could help learners study concretely via a built-in digital assistant that would actively propose learning activities at the beginning of rides. While only about 20 percent of respondents wanted no active proposals, preferences regarding how to trigger proposals differed. Respondents indicated they would value "smart" triggers the most. For example, while only 35 percent said they would like a "blank" proposal at the beginning of every ride, the most popular option, liked by 43 percent of respondents, would be a smart algorithm solution that proposed language-learning activities based on individual study preferences. These might include not suggesting a session after a business meeting. This choice shows that consumers increasingly expect software and applications to be smart and individualized to their needs.

Taking this scenario one step further into the world of AVs, the Lab provided respondents with different options on how the overall ride might support their language-learning needs. Ideas ranged from employing artificial intelligence to propose tailored study activities (e.g., fewer reading exercises on anticipated bumpy roads) to changing the overall route to fit the learning objectives.

Seeking an intelligent fit with the ride ahead. Respondents across all surveyed countries wanted an intelligent fit between planned activities and the ride ahead. However, stark differences emerged between regions as far as changing the overall route to fit the learning objectives. About 60 percent of Germans viewed it positively, whereas a staggering 94 percent

of Chinese respondents said the same. Whatever the reasons for the gap, it highlights the importance of understanding regional differences and tailoring offerings accordingly in a globalized market.

Understanding the advantages of experiments. MXT Lab research shows that the actual development of in-car language learning can be trickier than once thought. Issues include deciding when to learn, how to trigger learning, which display technologies to choose, and what interior concepts to apply – all aspects that stress the need to involve customers early and to gain a good understanding of their preferences and behaviors in order to develop a successful solution for the market.

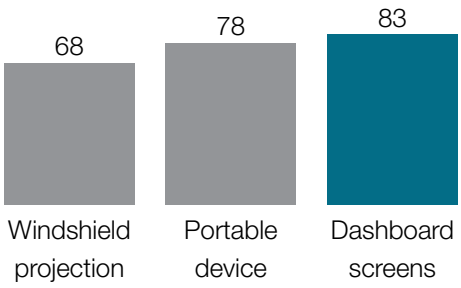
Experience reveals the limitations of the traditional survey approach, which, for example, could not clearly identify consumer attitudes toward new HMI technologies. Instead, using modular, highly flexible demonstrators at the MXT Lab, researchers could make features like visual content displays and car interior adjustments more experienceable and thus bring feature preferences to life for language learning in user tests.

Exhibit 3

Specifically looking at potential in-car language learning features in autonomous vehicles, we generated a number of insights on technologies and features for further research

Ways of studying

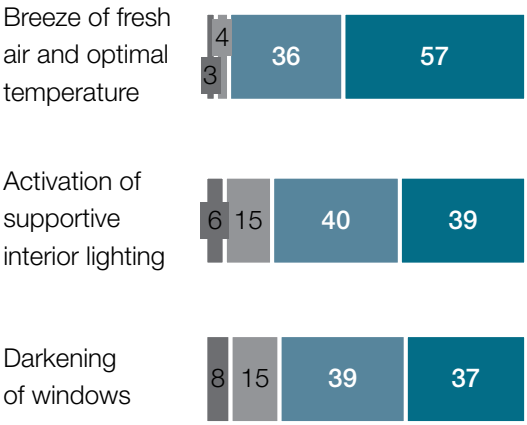
Preference for visual content display
Share of respondents in percent[1]



Respondents are willing to **explore different technologies** to watch visual content; dashboard screens currently only in-car technology widely available

Support studying

Concentration support features
Share of respondents in percent



Respondents with positive attitudes towards an in-car **environment actively supporting them**

1 Respondents who stated "Like" or "Rather Like" for respective options

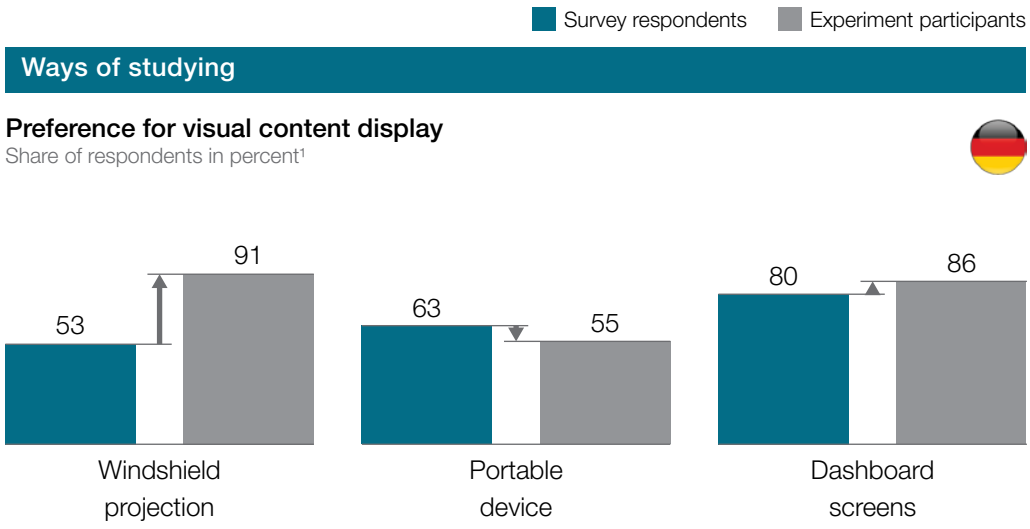
SOURCE: MXT Lab survey on in-car language learning; September 2018, n = 1,510

To confirm the online survey results, the Lab tested a row of potential features in its demonstrator with various groups of German respondents who were comparable (e.g. age, education, sex) to the groups that answered the online questionnaire. In all, it conducted real-life user tests with more than 20 people.

Regarding the question of consumer preferences for display technologies, the MXT Lab found that experiments enabled it to gain much more granular responses. The experimental results showed a clear preference for vehicle-integrated ways of displaying content over the use of a consumer's mobile devices. What's more, while the results for "known" technologies like portable devices and in-dashboard screens did not differ much between the survey and experiments, the feedback gathered on innovative windshield projection solutions was quite different. While only about half of survey respondents had a positive attitude towards this technology, more than 90 percent of participants in the experiments viewed it positively.

Exhibit 4

Specifically looking at potential in-car language learning features in autonomous vehicles, we generated a number of insights on technologies and features through a survey and experiments



Respondents are willing to **explore different technologies** to watch visual content; while survey respondents almost indifferent to technologies, actual **demonstrator experiments enabled identification of clear preferences**

Initial analyses show generally positive attitudes towards technological support of in-car language learning and requirement to create a dedicated environment – specific feedback on emerging technologies required user-testing on demonstrator for validation

1 Respondents who stated "Like" or "Rather Like" for respective options
SOURCE: MXT Lab survey on in-car language learning; September 2018, n = 1,510; Germany n = 503; MXT Lab Demonstrator experiments Germany January 2019, n = 22

Why the discrepancy? Likely because respondents could experience the head-up display in person in a setting that allowed them to imagine what it would feel like to sit in a real vehicle. Elements of the experiment included an interactive dashboard, a moveable monitor, and specifically designed seats in the demonstrator while online respondents could not rely on any such additional information or experiences.

The user tests also enable a more nuanced view into preferences for certain features. Overall, more than 75 percent of experiment participants preferred active support by the vehicle to help them concentrate and learn, be it through optimized air conditioning, supportive lighting, or the darkening of windows. For example, the MXT Lab saw strong results for active learning support features, such as the activation of bright lighting. In this case, 86 percent of experiment participants gave it the highest rating, versus only 29 percent of online survey respondents.

A deeper view regarding these answers again revealed more granular data than the online survey results could provide on preferences. A feature containing optimized temperatures and a breeze of fresh air to support learning concentration generated 90 percent positive ratings in the online survey in Germany, and respondents exposed to experiments gave it a 100 percent positive rating. While this might not seem like a significant difference at first, a closer look reveals that only 57 percent of survey respondents gave this feature the highest rating, while in the experiments, all respondents did.

In summary, these insights show how important it is for manufacturers and service providers to integrate user tests into their development processes early on. What's more, a real-life experiment and direct user feedback can provide crucial insights, especially concerning new technologies.

4, 5 | Conceptualization and quantification

Once organizations have evaluated a new product or service idea, they need to develop a broader business concept and initial quantification of its market value. Many companies today make this a largely internal step, based on known business models and development approaches. However, the increasing connectedness of mobility experience solutions and the participation of more partners and collaborators in the development and offering stages make the internally focused approach very limiting, as concepts and markets might change with the integration of new partners.

Building concrete bridges. To build a bridge between early-stage ideas and concrete product and service development processes, the MXT lab offers room for the analysis of future business models and the quantification of promising ideas that enable leaders to make "do-or-don't" decisions at an early stage. It does that by involving potential partners and collaborators from the start through an ecosystem of mobility-related players.

To establish an initial estimate for the value of a potential in-car language-learning solution, the MXT Lab gauged the willingness of survey participants to pay based on multiple learning program offerings. For the most popular format of an interactive learning program, almost

90 percent of global respondents expressed a willingness to pay up to USD 6 per month, a value roughly in line with subscription prices of currently popular smartphone language-learning apps like Duolingo or Babbel. Potentially accounting for the fact that an in-car solution could be more immersive than a smartphone solution, over three-quarters of respondents said they would pay up to USD 20 per month. Likewise, over 55 percent said they would pay up to USD 50 per month, showing that an in-car solution would be valued very highly by a large share of potential customers.

Looking specifically at Germany, the share of customers is slightly lower: around 83 percent of customers were willing to pay up to USD 6 per month and 40 percent of customers expressed willingness to pay up to USD 50 per month. However, when viewed in relation to the number of installations of current language-learning programs with millions of downloads for German Android users alone, it shows that the German market by itself could already achieve a significant size and value for in-car solutions.

Conclusion and outlook

The McKinsey Center for Future Mobility and the Fraunhofer IAO in Stuttgart have jointly established an innovative Mobility Experience and Technology Lab. It enables automotive players to discuss ideas and actively tackle the challenges and opportunities of a fully connected and increasingly autonomous future via breakthrough research and prototyping methods and tools.

The Lab represents an ecosystem where mobility players can collaborate, develop and test mobility experiencenew ideas in an environment that enables rapid iterations. It lets companies step beyond normal theoretical concepts and abstract evaluations to make those critical early product-shaping decisions. The goal is to have all stakeholders engage each other to find new synergies, and to do it much more rapidly.

By adopting a brand-new research approach focused on ideation, creation, evaluation, conceptualization, and quantification, we aim to address common challenges and shortcomings in typical R&D processes and decision making. So far, the Lab has conducted a first research project on in-car language learning. In the future, members and participants will shape the Lab's ongoing agenda to generate and test new, high-value ideas and solutions for the mobility experience of the future.

Having discussions with players across industries in an ecosystem involving not only OEMs and suppliers, but also mobility players, content providers, and start-ups is extremely insightful and valuable to us

– Tier-1 supplier

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